EXHIBIT 2

United States District Court
Eastern District of Oklahoma

Cynthia & Douglas Lakey Plaintiff, v. City of Wilson, et al, Defendants.	No. 20-cv-152-RAW

EXPERT REPORT OF MARK KROLL, PhD, FACC, FHRS, FIEEE, FAIMBE

This report summarizes my analysis and findings and includes a statement of my opinions. The report also includes data and other information considered by me in forming my opinions and sets out my qualifications (including my CV which is an integral part of this report).

Mark Kroll, PhD, FACC, FHRS, FAIMBE 1 April 2022

This report has numerous photos and tables using color and should only be printed with a color printer.

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Glossary & Abbreviations

1. *Conducted electrical weapon (CEW): handheld probe-launching electrical weapon*
2. *To control electronically: to successfully use a CEW*
3. *Electronic control: the goal of controlling electronically*
4. *Deployment: launch of probes*
5. *Electrocution: death from electricity*

Brief Summary of Qualifications

I am a Biomedical scientist with a primary specialty in bioelectricity or the interaction of electricity and the body.* I have invested most of my career researching and developing electrical devices to diagnose and treat disease. The primary focus is the effect of electrical shocks on the human body.

This involves researching, lecturing, and publishing on electric shocks and their effects on the human body. It includes lectures throughout Europe, South America, and Asia (in 35 countries) as well as at many of the major universities and medical centers of the United States (U.S.). Usually, the typical audience member is a cardiologist electrophysiologist, medical examiner, or forensic pathologist. With over 380 issued U. S. patents and numerous pending and international patents, I currently hold the most patents on electrical medical devices of anyone in the world. Over 1 million people have had devices with some of these patented features in their chest, monitoring every heartbeat. http://bme.umn.edu/people/adjunct/kroll.html.

In 2010 was awarded the Career Achievement Award by the Engineering in Medicine and Biology Society (EMBS) of the Institute of Electrical and Electronics Engineers (IEEE) which is the most prestigious award given internationally in Biomedical Engineering.
http://tc-therapeutic-systems.embs.org/whatsnew/index.html

Believed to be the only individual to receive the high "Fellow" honor from both Cardiology and Biomedical societies. To wit:

1997 Fellow, American College of Cardiology
2009 Fellow, Heart Rhythm Society
2011 Fellow, IEEE Engineering in Medicine and Biology Society
2013 Fellow, American Institute for Medical and Biological Engineering

Author of over 200 abstracts, papers, and book chapters and also the co-editor of 4 books including the only 2 scientific treatises on Conducted Electrical Weapons (CEW):

1. TASER® Conducted Electrical Weapons: Physiology, Pathology and Law. Springer-Kluwer 2009.
2. Atlas of Conducted Electrical Weapon Wounds and Forensic Analysis: Springer-Kluwer 2012.

*See current CV for further details and specifics. My curriculum vitae containing details of my relevant formal education, experience, and publications authored is attached and made an integral part of this report.

Directly relevant paper publications include over 100 papers, books, book chapters, indexed letters on CEWs and arrest-related death (ARD), and numerous scientific meeting abstracts. For more details please see CV at:
https://www.dropbox.com/sh/wju0hu6q3ca62xx/AAAlzTlLbKbxu5m34AsMfCrYa?dl=0

There have also been many presentations on CEWs to scientific, medical, pathology, as well as law enforcement, audiences. These include: 2007 American Academy of Forensic Science (AAFS) conference major presentation in San Antonio, Texas and the 2007 BEMS (Bio-electromagnetic Society) meeting Plenary Address in Kanazawa, Japan.

1. Major invited lecture at the 2006 NAME (National Association of Medical Examiners) conference in San Antonio, Texas.
2. Advanced Death Investigation Course of St. Louis University (2007) as faculty lecturer to full audience.
3. Faculty lecturer to full audience at Institute for the Prevention of In-Custody Death Conferences (2006 and 2007), Las Vegas, Nevada.
4. Chair of special session on TASER CEW at 2006 Cardiostim meeting in Nice, France.
5. Guest lecture to U.S. Military on CEW in 2006.
6. "Presenting Rhythm in Sudden Custodial Deaths After Use of TASER® Electronic Control Device," was presented at the 2008 scientific conference of the Heart Rhythm Society.
7. "Can Electrical-Conductive Weapons (TASER®) alter the functional integrity of pacemakers and defibrillators and cause rapid myocardial capture?" was presented at the 2008 scientific conference of the Heart Rhythm Society.
8. "Weight-Adjusted Meta-Analysis of Fibrillation Risk From TASER® Conducted Electrical Weapons" presented at the 2009 AAFS conference.
9. "Meta-Analysis of Fibrillation Risk From TASER® Conducted Electrical Weapons as a Function of Body Mass" presented at the 2009 scientific conference of the Heart Rhythm Society.
10. Oral presentation at the 2014 NAME (National Association of Medical Examiners) conference in Portland, Oregon.
11. Pathophysiological Aspects of Electroshock Weapons. University of Salzburg Electroshock Weapon Symposium. Salzburg, Austria. July 2015.
12. Real and Imagined Risk of Electrical Weapons. University of Salzburg Electroshock Weapon Symposium. Salzburg, Austria. Dec 2016.

In addition to the major addresses above, there have been lectures and presentations at the U.S. Department of Justice (2007), AAFS (2006), and BEMS (2006) regarding TASER CEWs.

I have deployed and discharged TASER CEWs numerous times and have personally experienced a TASER® X26 CEW probe deployment discharge to the center of my chest.

Relevant Committees and Boards:

1. International Electrotechnical Commission (IEC) (Geneva, Switzerland) TC64 MT4 Committee. This committee is the top international authority for setting the international electrical safety limits for electrocution and other electrical dangers.
2. American Society for Testing and Materials) ASTM, Committee: E54 Homeland Security Applications, Subcommittee: E54.08 Operational Equipment, including Less-Lethal Task Group, including: ASTM (draft) Standard WK61808 New Test Method for Correct Performance of Less-Lethal Electroshock Weapons Used by Law Enforcement and Corrections.
3. Axon Enterprise, Inc. (Axon né TASER), corporate and also Scientific and Medical Advisory Board.
4. ANSI (American National Standards Institute) standards committee on electrical weapons.

Courtroom testimony in U.S., Australia, and Canada, and retained expert in the United Kingdom and France. I also have significant research, publications, and testimony in the areas of resuscitation, ARDs (arrest-related death), prone restraint, and biomechanics.

Short Primer on Muscle Stimulators and Electrocution

A Muscle Stimulator is a Muscle Stimulator

Because electricity is invisible, and because the TASER® conducted electrical weapons (CEWs) are used by police — often in dangerous situations — a great deal of mythology and misunderstanding has grown up around them.

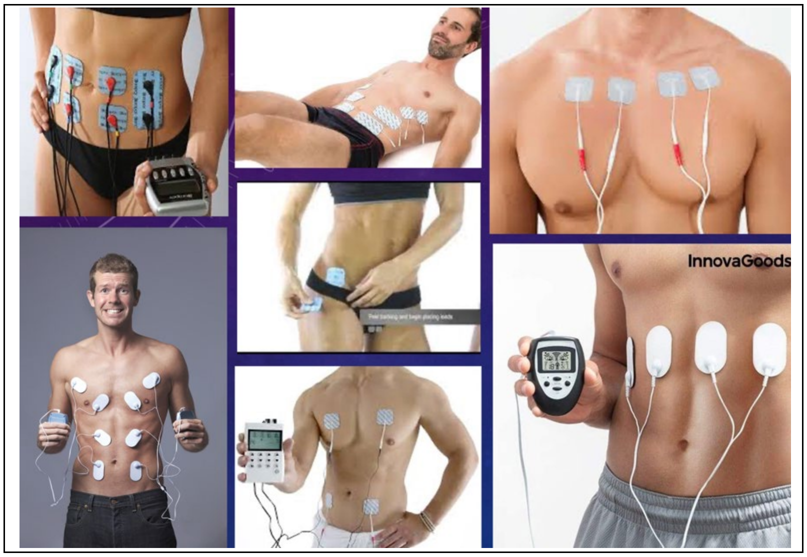

Figure 1. Electrical muscle stimulators are popular for therapy and training.

As seen in Table 1, some CEWs put out slightly more current ***per channel*** than do the tested therapeutic muscle stimulators.[1] Note that the Obovov R-C4D puts out slightly more current (1.34 mA) than does the X26P CEW (1.3 mA). For total current injected into the body the iStim EV-805 delivers 3.29 mA over 4 channels (8 electrodes). This exceeds the 3.13 mA total output of the newer T7 CEW. This also exceeds the total current output (1.3 mA) of the X26P which has only a single channel.

Table 1. Muscle stimulation capability of popular EMS units and CEWs

Model	d (μs)	Raw Charge (μC)	Normalization Factor	Normalized Charge (μC)	Pulse Rate (PPS)	Iagg Normalized (mA)	Channels	Total Iagg (mA)
EMS 7500	301	23.6	0.54	12.8	68.6	0.88	2	1.76
iStim EV-805	305	21.8	0.54	11.7	70.1	0.82	4	3.29
Obovov R-C4D	210	24.6	0.69	16.9	79.6	1.34	2	2.69
X2 CEW	71.2	65.3	1.14	74.2	19.6	1.45	2	2.91
X26P CEW	98.6	65.7	1.01	66.1	19.6	1.30	1	1.30
T7 CEW	60	59.2	1.20	71.0	22.0	1.56	2	3.13

All readings with 500 Ω load. Iagg = aggregate current per ANSI CPLSO-17.

An important issue is the application duration for safety. The U.S. FDA (Food and Drug Administration) typically approves muscle stimulators for maximum durations of 40 to 45 minutes as seen in Figure 2.

10.2 Output Specifications

The following information has been compiled using the "Guidance Document on Powered Muscle Stimulator 510(k)s, 1999".

Table I **Basic Unit Characteristics**	**New Device** SLENDERTONE® Evolve Abs, Type 735	**Predicate Device** SLENDERTONE® CoreFit Abs 8, Type 734	**Comparison**
9. Automatic overload Trip?	Yes	Yes	Identical
10. Automatic No-Load Trip?	Yes	Yes	Identical
11. Automatic Shut Off	Yes	Yes	Identical
12. Patient Override Control?	Yes, pause button stops treatment immediately.	Yes, pause button stops treatment immediately.	Identical
13. Indicator Display - On/Off Status? - Low Battery? - Voltage/Current Level?	 Yes, OLED Display Yes, OLED Display Yes, OLED Display	 Yes, OLED Display Yes, OLED Display Yes, OLED Display	Identical
14. Timer range (minutes)	2 - 45 minutes	20-40 minutes	Different but no impact on safety or effectiveness.
15. Compliance with Voluntary Standards?	IEC 60601-1 IEC 60601-2-10 EN 60601-1-2 IEC 60601-1-11 IEC 60601-1-6 IEC 62133 FCC (47 CFR Part 15, Subpart B)	IEC 60601-1 IEC 60601-2-10 EN 60601-1-2 IEC 60601-1-11 IEC 60601-1-6 IEC 62133 FCC (47 CFR Part 15, Subpart B)	Identical

Figure 2. FDA approved outputs for Slendertone® abdominal muscle stimulator.

Whole body electro-myostimulation (WB-EMS) is an new extreme athletic training technique that recently originated in Germany with a device called the Miha Boytec.[2] The subject strips naked and then dons the electrode jacket as shown in Figure 3. Additional electrodes are placed on the legs.

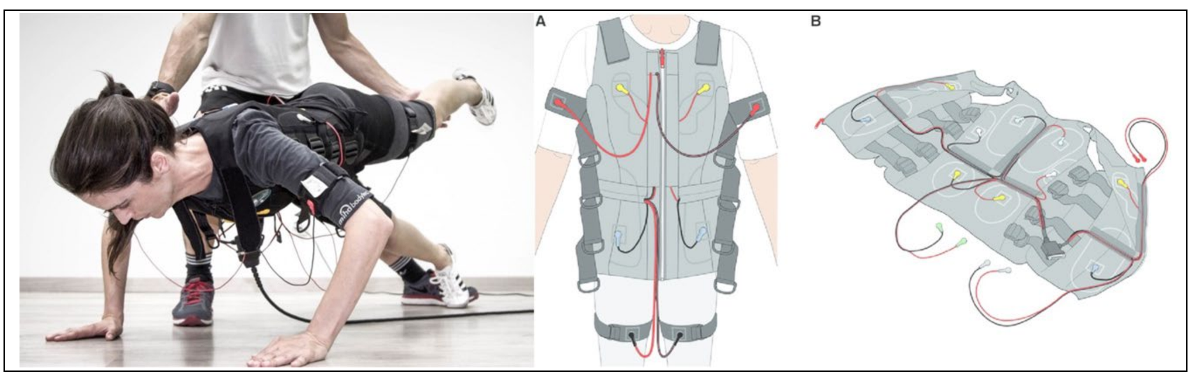

Figure 3. Miha Bodytec WB-EMS electrode vest.

The outputs for the Bodytec, E-fit and Katalyst are given below.[3-5]

Table 2. Comparison of X26 CEW to the Bodytec system.

	Bodytec	E-fit	Katalyst	X2	X26P	T7
Channels	10	12	10	2	1	2
Max Pulse rate (PPS)	150	120	85	19.6	19.6	22
Pulse duration (μs)	50-400	100-500	175	71	98	60
Typical duration (minutes)	20	30	20	< 3	< 3	< 3
Pulse charge (μC)*	32	36	21	65	65.7	59.2
Aggregate current (mA)	4.8	4.3	1.8	1.3	1.29	1.30
Aggregate current over all channels (mA)	48.0	51.8	17.9	2.6	1.29	2.60

*Non-normalized raw charge is used as the exact pulse durations are not disclosed for the Bodytec and E-fit.

As seen in Table 2, there is a world of difference between the level of stimulation between an X26P CEW and the Miha Bodytec WB_EMS system. The Bodytec delivers almost 4 times the current per electrode pair and almost 40 times the total current to the body.[1]

The only side-effect from these body-stimulators has been rhabdomyolysis which has made some athletes sick but is not fatal.[2,6-9] TASER® CEWs do not cause rhabdomyolysis.[10-17]

Sadly, some well-intended police advisory groups have confused the baseball tactical rule with some sort of a safety limitation.[18] For details see "The Dogma Of 3 Strikes And 15 Seconds" section on page 52. The idea that 16 seconds of muscle stimulation is somehow dangerous when the FDA approves such muscle stimulation out to 40 minutes is so wrong that it is sadly laughable.

There are 2 fundamental differences between therapeutic muscle stimulators and the CEW:

1. The therapeutic muscle stimulators deliver current through adhesive patches while the CEW uses probes as the application is usually non-voluntary.
2. The therapeutic muscle stimulators are regulated by specific standards (ANSI & IEC) for electronic muscle stimulators while the CEW is regulated by a specific ANSI standard for electrical weapons.[19-21]

The safety of long-duration electronic muscle stimulation is so well established that it comes as a surprise to bioelectrical scientists that there is any ignorance on this issue. However, in the criminal case, prosecutor Ladd suggested to Ofc. Taylor (Transcript 681:23) that 4 minutes was dangerous:

> Q. You would agree four minutes is getting to the danger zone, right?
> A. I believe that there was -- it could be, yes.

Prosecutor Ladd did not identify the source of his belief if it indeed was a sincere belief.

Fundamental Rules of Electrocution

It is important to understand that a death from electricity is called an electrocution. Here is what the dictionaries have to say about "electrocution:"

> to kill by electricity: Dictionary.com
>
> to send electricity through someone's body, causing death: Cambridge Dictionary
>
> to execute (a criminal) by electricity or to kill by a shock of electricity: Merriam-Webster Medical Dictionary

Comment: Electrocution is simply a death from electricity without the involvement of exogenous trauma (such as gasoline fumes or hard objects). This should be well-established and obvious, but it still comes up as sometimes someone will say that the CEW killed someone but not by electrocution. This is, of course, logically impossible.

There are 3 basic rules established by 140 years of electrocution research:[22-30]

1. Electrocution is a stand-alone cause of death.
    a. It does not combine with other maladies like salt and pepper combining to flavor a soup.[18]
2. Electricity does not build up like poison.
    a. If the current is high enough, and the pathway is appropriate, electrocution either occurs in the first 1-5 seconds or does not occur at all.
    b. See Antoni,[31] Wegria,[32] Ferris,[33] Jacobsen,[34] Roy,[35] Scott,[36] and Kiselev.[37]
    c. This is also recognized by the international electrical safety standards and those of Underwriters Laboratory.[38]
3. Electrocution is not caused by pain.
    a. If pain could stop someone's heart, then women would not tend to survive childbirth and the passage of kidney stones would tend to be fatal.

In spite of over a century of research, some people — either out of false intuition or simple malice — promote the poison myth. In the criminal case, prosecutor Ladd asked Ofc. Taylor (Transcript 669:13):

> Q. You don't think there was some lasting effects from the tasers?
> A. Maybe. I'm not a doctor. I'm not sure what his effects were.

Brief Summary of Important Background Facts

1. Major studies sponsored by the US DOJ show that use of electronic control reduces the suspect injury rate by at least 2/3 compared to alternative force options, including hands-on physical force.[39,40] The MacDonald study covered 12 USA law enforcement agencies and 24,380 uses of force.[39] They found that the CEW reduced subject injury by 65%. Taylor et al analyzed data from 13 USA agencies including 16,918 uses of force and described a 78% reduction in injuries requiring medical attention.[40]

   The scientific literature is very clear that the choice of wrestling will triple (3x) the rate of suspect injury and quadruple (4x) the rate of serious injury, this was distorted in the associated criminal case. Nevertheless, in the criminal case, prosecutor Ladd suggested to Ofc. Taylor (Transcript 693:1):

   > Q. Does it seem less of a violent or aggressive thing for you, based own your experience as a police officer, to take your hands and try to put somebody in 'cuffs versus tasing them?

2. The probe punctures are not considered an injury. A probe-dart skin penetration is not considered an injury any more than a flu-vaccination would be considered an injury.[41] They both involve a skin puncture from a small needle.

   Nevertheless, in the criminal case, prosecutor Ladd suggested to Ofc. Dingman (Transcript 731:15):

   > Q. And, then, here on his back, do you see in State's 13 and 14, these holes in his back?
   > Yes, sir.
   > Q. And those would have been caused by the taser prongs that were deployed by you and Mr. Taylor; is that right?
   > Yes, sir.
   > Q. And you would agree those constitute injuries?

3. The use of electrical weapons reduces fatal officer involved shootings by 2/3 where the electrical weapon usage is not overly restricted.[42] The use of electrical weapons reduces the non-firearm arrest-related death rate by 2/3 compared to other force options.[43]

4. The X26E and X26P CEWs used by the agency deliver a safe level of electrical current as specified by the Underwriters Laboratories (UL) and International Electric Fence standards.[44] In fact, they satisfy all relevant electrical safety standards.[45-47] The original TASER® X26 CEW is now often referred to as the X26(E) to distinguish it from the newer X26P.

5. The X26P delivers ~1.6 W which satisfies the UL electric fence safety limit of an equivalent of 5 W and even the more conservative 2.5 W international

limit.[48,49] The X26(E) delivers ~1.8 watts (W) which satisfies the UL electric fence safety limit of an equivalent of 5 W and even the more conservative 2.5 W international limit.[48,49]

6. The UL electric fence safety standard allows the delivery of 5 watts for short pulses as those from the X26E and X26P.

7. The X26P CEW satisfies the ANSI CPLSO-17:2017 "Electrical Characteristics of ECDs and CEWs" standard.[50]

8. The effects, of electronic control, are over essentially instantaneously after the current ceases. Subjects are able to complete simple tasks within 1.3 seconds.[51] Multiple studies have shown that subjects can immediately operate a keyboard and perform computer testing.[52-55]

9. Electrical current is not more dangerous for those on drugs or suffering from mental illness. In fact, cocaine is a sodium channel blocker and tends to blunt the effects of electricity.{Tisdale, 1996 #717}{Lakkireddy, 2006 #5087}

10. The occasional opinion — that electronic control should not be used with the intoxicated (or mentally ill) — does not comport with the realities of law enforcement. That reality is that well-adjusted and sober members of society do not tend to be involved in forceful arrests as 79% of recipients of force have a history of mental illness or substance abuse and 66% have a documented history of mental illness.[90] More specifically to drug abuse, a large study found that 71% of electronic control subjects had drugs in their urine and 73% had a substance abuse history.[91] A large Canadian forceful-arrest study found that 82% of the subjects were being affected by alcohol, drugs, or emotional disturbance.[92] The suggestion that CEWs not be used on the mentally ill (including those in excited delirium) or those intoxicated by drugs or alcohol would exclude the very people that most often resist being placed in custody. Also, prolonged continuous CEW exposure in the setting of acute alcohol intoxication has no clinically significant effect on subjects in terms of markers of metabolic acidosis. The acidosis seen is consistent with ethanol intoxication or moderate exertion."[93] Sober and rational people generally do not resist law enforcement officers.

Brief Summary of Opinions in This Case

1. Ofc. Taylor exhibited significant restraint in his use of his CEW. In 13 of his trigger pulls, he took the affirmative step of flipping the safety down to turn the output OFF so the normal programmed 5-second duration did not occur.

2. Ofc. Taylor deployed from 2 cartridges. Deployment #1 had no effect as a probe missed. Deployment #2 landed 2 probes in the right upper back and delivered 2024 pulses of current. The probes were so close together (2.5 – 3.0 inches) that there was no NMI (neuromuscular incapacitation).

3. Ofc. Dingman deployed from 2 cartridges. Deployment #1 landed 2 probes in the front center abdomen and delivered 283 pulses of current. The probes were in the protruding abdomen so that there was no NMI (neuromuscular incapacitation). Deployment #2 had no effect as a probe missed.

4. Mr. Lakey had his cardiac arrest about 7.5 minutes after the last probe-mode shock delivery thus eliminating the possibility of electrocution.

5. Mr. Lakey was sitting up about 2 minutes after the last probe-mode shock delivery thus eliminating the possibility of electrocution.

6. Mr. Lakey's cardiac arrest rhythm was asystole thus eliminating the possibility of electrocution.

7. No probe was close to Mr. Lakey's heart thus eliminating the possibility of electrocution.

8. The usage of the electrical weapons did not cause Mr. Lakey's tragic death.

9. The usage of the electrical weapons did not contribute to Mr. Lakey's tragic death.

Trigger Pulls

The X26P downloads were analyzed for connection quality. Low charges ($Q < 40$ μC) indicate zero connection to the body. $Q < 5$ (μC) shows no connection while charges of $5 < Q < 40$ μC suggests probes in soil or grass. Trigger pulls with high standard deviation $\sigma(Q) > 5$ suggest probe movements or muzzle arcing.[50,56,57] Averaged values of Q, V_{arc}, and V_{stim} were used. Trigger pulls with $Q \geq 60$ μC were analyzed with the published formula:

$R = 4.94[V_{arc}/Q]^2 + 9.3\sqrt{V_{stim}} - 908\ \Omega$

Table 3. Taylor Trigger Pulls.

Seq	n	Q (μC)	stdev(Q)	Varc	Vstim	Connection
2980	225	63.6	3.07	833	1546	Arc: sd(Q)= 3.1
2983	86	61.6	8.86	891	1801	Unstable: sd(Q)= 8.9
2984	46	63.0	0.88	863	1766	411 Ω
2987	11	67.1	1.51	903	2072	409 Ω
2990	14	63.8	1.78	888	1609	422 Ω
2995	87	62.3	5.68	876	1768	Unstable: sd(Q)= 5.7
2996	44	63.0	1.11	863	1832	418 Ω
2999	85	62.9	1.92	863	1817	419 Ω
3000	15	62.4	1.63	862	1635	409 Ω
3003	34	62.8	1.62	873	1689	427 Ω
3006	14	62.2	15.61	954	2595	Unstable: sd(Q)= 15.6
3009	57	59.0	11.41	917	2289	Unstable: sd(Q)= 11.4
3012	85	63.0	1.30	888	1754	464 Ω
3013	85	62.9	2.03	837	1683	349 Ω
3014	85	62.9	1.49	882	1833	462 Ω
3015	85	63.0	1.34	883	1740	451 Ω
3016	85	63.0	1.22	882	1792	455 Ω
3017	22	62.9	1.69	883	1737	453 Ω
3020	85	63.0	1.87	884	1792	458 Ω
3021	67	62.8	3.10	884	1908	475 Ω
3024	85	63.0	2.01	855	1683	384 Ω
3025	23	62.5	1.91	910	1834	537 Ω
3028	49	63.0	2.10	824	1474	294 Ω
3031	85	63.1	1.38	904	1730	494 Ω
3032	85	63.1	1.56	883	1773	451 Ω
3033	85	63.0	2.03	867	1640	406 Ω
3034	85	63.2	1.67	842	1705	352 Ω
3035	85	63.1	1.89	843	1729	359 Ω
3036	53	62.9	1.54	842	1719	364 Ω
3039	84	16.5	27.05	978	3119	Grass/soil: Q= 16.5

Table 4. Dingman Trigger Pulls.

Seq	n	Q (μC)	stdev(Q)	Varc	Vstim	Connection
4090	82	62.9	2.22	899	2160	533 Ω
4091	84	63.0	2.24	847	1977	399 Ω
4092	84	63.3	2.20	846	1732	361 Ω
4093	83	0.9	1.38	982	3459	None: Q= 0.9
4094	62	38.2	24.04	1115	3581	Grass/soil: Q= 38.2
4095	60	24.4	16.32	1122	3795	Grass/soil: Q= 24.4
4096	77	16.0	16.52	991	3463	Grass/soil: Q= 16.0
4097	82	13.5	14.21	985	3457	Grass/soil: Q= 13.5
4098	84	8.3	1.58	984	3468	Grass/soil: Q= 8.3
4099	83	10.8	1.47	983	3466	Grass/soil: Q= 10.8
4100	83	12.6	6.12	984	3463	Grass/soil: Q= 12.6
4101	83	12.6	1.32	984	3459	Grass/soil: Q= 12.6
4102	83	11.3	1.31	983	3465	Grass/soil: Q= 11.3
4103	83	10.5	1.58	983	3465	Grass/soil: Q= 10.5
4104	101	11.1	1.39	984	3465	Grass/soil: Q= 11.1
4105	84	11.6	1.08	983	3463	Grass/soil: Q= 11.6
4106	83	9.5	1.16	983	3458	Grass/soil: Q= 9.5
4107	36	9.2	0.83	982	3458	Grass/soil: Q= 9.2
4110	64	31.2	24.25	1120	3707	Grass/soil: Q= 31.2
4111	82	1.2	1.48	984	3479	None: Q= 1.2
4112	83	1.3	1.49	984	3482	None: Q= 1.3
4113	83	1.3	1.49	985	3482	None: Q= 1.3
4114	90	1.3	1.50	981	3486	None: Q= 1.3

Timelines

Video Synchronization

I took the download analysis report generated by Brian Chiles on 7 May 2021 as the source of trigger pull times. I then matched the pulse-graph times with the consolidated video as seen in Table 5. The Dingman pulse-graph times were 6 or 7 seconds slow compared to the video while the Taylor pulse graph times were 5 seconds slow.

Table 5. Synchronization of pulse graph times with the video.

Time	Event	Source	Dingman Deltas	Taylor Deltas
23:58:50	Taylor TP #1	Pulse Graphs		
23:58:55	Taylor Deploy #1	Synced Video		0:00:05
23:58:56	Dingman TP #1	Pulse Graphs		
23:59:03	Dingman Deploy #1	Synced Video	0:00:07	
23:59:14	Taylor changed cartridge	Synced Video		
23:59:24	Dingman TP #2	Pulse Graphs		
23:59:30	Reaction. Dingman TP2	Synced Video	0:00:06	
23:59:45	Dingman TP #3	Pulse Graphs		
23:59:52	Reaction. Dingman TP3?	Synced Video	0:00:07	
24:00:08	Taylor TP #2	Pulse Graphs		
24:00:13	Taylor Deploy #2	Synced Video		0:00:05
24:00:21	Taylor TP #3	Pulse Graphs		
24:00:26	Pain reaction	Synced Video		0:00:05

The Dingman trigger-pull times had 7 seconds added and the Taylor times had 5 seconds added in order to merge the Trigger Pull timelines of Table 3 and Table 4 into a timeline of highlights from the video. See Table 6.

Table 6. Master Timeline

PG Seq.	*Time*	*Event*	Connection
2980	23:58:55	Taylor TP #1. Lakey Continues to get up to all 4's.	Arc: σ(Q)= 3.1
4090	23:59:03	Dingman TP #1. Red dot, probes to belly. Lakey has leg control.	533 Ω
	23:59:07	Taylor TP #1 END	
	23:59:08	Dingman TP #1 END	
	23:59:14	Taylor probe visible on ground. Taylor changed cartridge	
4091	23:59:31	Dingman TP #2. Lakey yells but can roll over.	399 Ω
	23:59:36	Dingman TP #2 END	
4092	23:59:52	Dingman TP #3. Lakey yells but has leg control.	361 Ω
	23:59:57	Dingman TP #3 END	
4093	24:00:11	Dingman TP #4	None: Q= 0.9
	24:00:12	Lakey stands quickly. Taylor Deploy #2	
2983	24:00:13	Taylor TP #2	Uns: σ (Q)= 8.9
	24:00:15	Lakey slowly goes down. (1.8 seconds). Minimal effect	
	24:00:16	Dingman TP #4 END	
	24:00:17	Lakey rolls over, minimal effect	
	24:00:18	Taylor TP #2 END	
2984	24:00:26	Taylor TP #3. Yells.	411 Ω
	24:00:29	Dingman changed cartridge	
	24:00:29	Taylor TP #3 END	
2987	24:00:34	Taylor TP #4	409 Ω
	24:00:35	Taylor TP #4 END	
2990	24:00:49	Taylor TP #5. Yells but no NMI.	422 Ω
	24:00:50	Taylor TP #5 END	
4094	24:00:52	Dingman TP #5	Grass: Q= 38.2
	24:00:52	Dingman Deploy #2 to back as Lakey gets up. Crackling.	
2995	24:00:53	Taylor TP #6. Lakey goes back down but can roll. No NMI.	Uns: σ (Q)= 5.7
	24:00:57	Dingman TP #5 END	
	24:00:58	Taylor TP #6 END	
2996	24:01:22	Taylor TP #7	418 Ω
4095	24:01:22	Dingman TP #6. Crackling showing zero connection.	Grass: Q= 24.4
	24:01:25	Taylor TP #7 END	
2999	24:01:26	Taylor TP #8	419 Ω
	24:01:27	Dingman TP #6 END	
	24:01:31	Taylor TP #8 END	
3000	24:01:52	Taylor TP #9	409 Ω
	24:01:53	Taylor TP #9 END	
4096	24:01:57	Dingman TP #7. Crackling.	Grass: Q= 16.0
3003	24:01:57	Taylor TP #10. Yells but able to roll around.	427 Ω
	24:01:59	Taylor TP #10 END	
	24:02:02	Dingman TP #7 END	
3006	24:02:34	Taylor TP #11	Uns: σ (Q)= 15.6
	24:02:35	Taylor TP #11 END	
3009	24:02:56	Taylor TP #12	Uns: σ (Q)= 11.4
	24:03:00	Taylor TP #12 END	
3012	24:03:01	Taylor TP #13	464 Ω
4097	24:03:01	Dingman TP #8. Lakey gets up. Obviously, no NMI.	Grass: Q= 13.5
	24:03:06	Dingman TP #8 END	

	24:03:06	Taylor TP #13 END	
4098	24:03:07	Dingman TP #9	Grass: Q= 8.3
	24:03:12	Dingman TP #9 END	
3013	24:03:17	Taylor TP #14	349 Ω
4099	24:03:17	Dingman TP #10	Grass: Q= 10.8
	24:03:22	Dingman TP #10 END	
	24:03:22	Taylor TP #14 END	
3014	24:03:31	Taylor TP #15	462 Ω
4100	24:03:32	Dingman TP #11	Grass: Q= 12.6
	24:03:36	Taylor TP #15 END	
	24:03:37	Dingman TP #11 END	
3015	24:03:44	Taylor TP #16	451 Ω
4101	24:03:46	Dingman TP #12	Grass: Q= 12.6
	24:03:49	Taylor TP #16 END	
	24:03:51	Dingman TP #12 END	
3016	24:04:03	Taylor TP #17	455 Ω
4102	24:04:04	Dingman TP #13	Grass: Q= 11.3
	24:04:08	Taylor TP #17 END	
	24:04:09	Dingman TP #13 END	
3017	24:04:25	Taylor TP #18	453 Ω
4103	24:04:25	Dingman TP #14	Grass: Q= 10.5
	24:04:27	Taylor TP #18 END	
	24:04:30	Dingman TP #14 END	
4104	24:04:41	Dingman TP #15	Grass: Q= 11.1
3020	24:04:41	Taylor TP #19	458 Ω
	24:04:46	Taylor TP #19 END	
	24:04:47	Dingman TP #15 END	
4105	24:04:48	Dingman TP #16. Zero response.	Grass: Q= 11.6
	24:04:53	Dingman TP #16 END	
3021	24:05:58	Taylor TP #20. Yells but no NMI.	475 Ω
	24:06:02	Taylor TP #20 END	
3024	24:06:04	Taylor TP #21	384 Ω
4106	24:06:05	Dingman TP #17	Grass: Q= 9.5
	24:06:09	Taylor TP #21 END	
	24:06:10	Dingman TP #17 END	
3025	24:06:17	Taylor TP #22	537 Ω
	24:06:19	Taylor TP #22 END	
4107	24:06:43	Dingman TP #18. Zero response.	Grass: Q= 9.2
3028	24:06:45	Taylor TP #23. Yells.	294 Ω
	24:06:46	Dingman TP #18 END	
	24:06:48	Taylor TP #23 END	
3031	24:06:52	Taylor TP #24. Yells but can still roll over and get up on hands.	494 Ω
4110	24:06:54	Dingman TP #19	Grass: Q= 31.2
	24:06:57	Taylor TP #24 END	
	24:06:59	Crackling. Dingman TP #19 END	
3032	24:07:03	Taylor TP #25. Yells but complete arm control.	451 Ω
	24:07:08	Taylor TP #25 END	
4111	24:07:18	Dingman TP #20	None: Q= 1.2
3033	24:07:18	Taylor TP #26	406 Ω
	24:07:23	Dingman TP #20 END	

	24:07:23	Taylor TP #26 END	
3034	24:07:24	Taylor TP #27	352 Ω
	24:07:29	Taylor TP #27 END	
3035	24:07:33	Taylor TP #28	359 Ω
4112	24:07:33	Dingman TP #21	None: Q= 1.3
	24:07:38	Dingman TP #21 END	
	24:07:38	Taylor TP #28 END	
4113	24:08:01	Dingman TP #22	None: Q= 1.3
3036	24:08:02	Taylor TP #29	364 Ω
	24:08:05	Taylor TP #29 END	
	24:08:06	Dingman TP #22 END	
4114	24:08:08	Dingman TP #23	None: Q= 1.3
3039	24:08:08	Taylor TP #30	Grass: Q= 16.5
	24:08:10	Lakey jumps up to knees	
	24:08:13	Dingman TP #23 END	
	24:08:13	Taylor TP #30 END	

Probe Landings

There were a total of 8 probes deployed in this incident yet the autopsy found only 6 probe landings. Probe landings onto bare skin leave a distinctive signature which is a 6 mm doughnut with a 1 mm puncture wound in the center. See Figure 4. I inspected the autopsy photographs carefully and agree with the medical examiners count of only 6 probe landings.

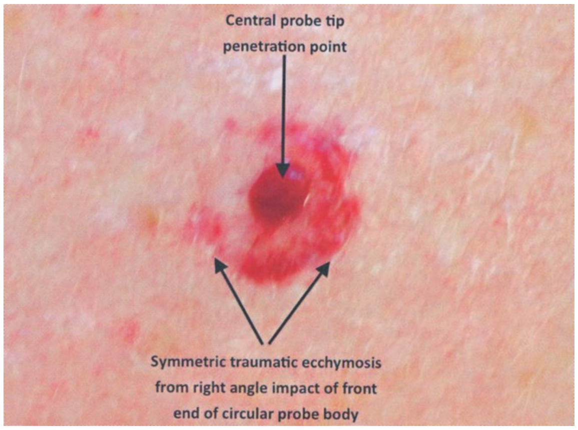

Figure 4. Probe landing on bare skin

Figure 5 shows the single probe landing from Taylor's 1st cartridge. The other probe in that cartridge missed Mr. Lakey. Both probes from Taylor's cartridge #2 landed but there were about 2.5 inches apart (perhaps 3 inches with chest expansion) and this provided an insufficient distance for neuromuscular incapacitation (NMI).

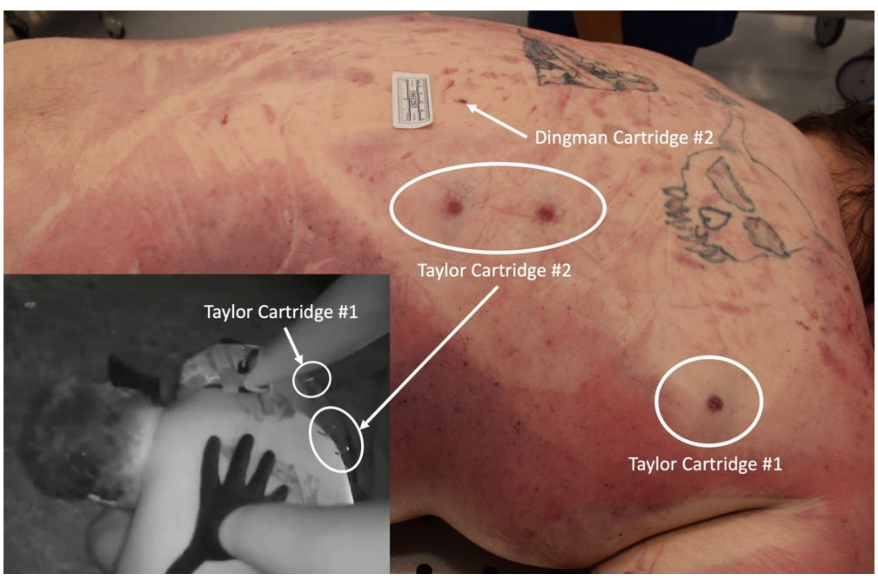

Figure 5. Probe landings on the back.

With a probe spread of ≤ 4 inches on the back there is no NMI as seen in Figure 6. With a better probe spread, this would normally have been a very effective

location as the current would have been delivered to the major motor neurons exiting from the spine.

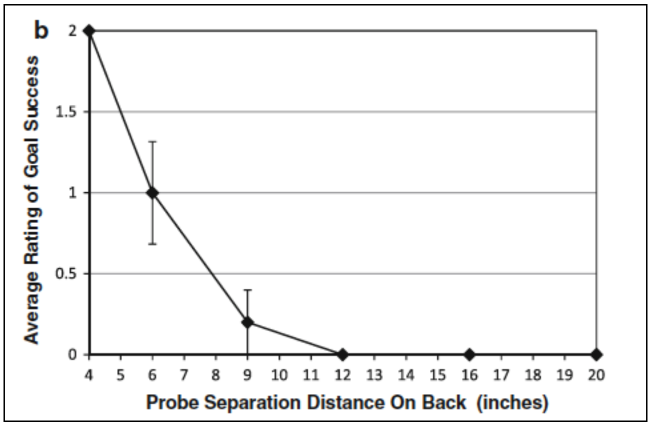

Figure 6. Subject's ability to control muscles as function of probe spread.

Dingman's 2nd cartridge only had a single probe landing and that was in the high center back. The other probe missed and that explains why there was zero effect from any of Dingmans trigger pulls from #5 to #23.

Figure 7 Shows the probe landings on the abdomen from Dingman's 1st cartridge. Even though there was a good probe spread, probe landings in the abdomen tend to be only marginally effective as the current is delivered too far from the spine. Due to Mr. Lakey's obesity, none of the current went down into the body as fat as such an effective insulator.[58]

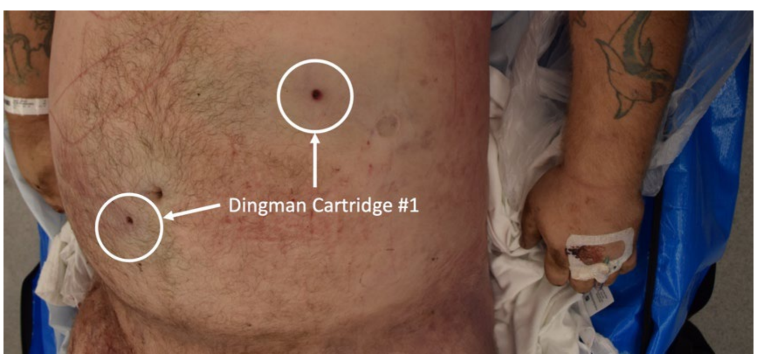

Figure 7. Probe landings on the abdomen.

Deployments

Taylor Deployment #1.

Taylor Deployment #1 occurred at 23:58:55 (video time) with a single prone landing in the right shoulder region while the other probe missed. See Figure 8. Since there was no completed circuit, there was no NMI and Lakey was able to continue to get up on all fours during this trigger pull (Taylor TP #1).

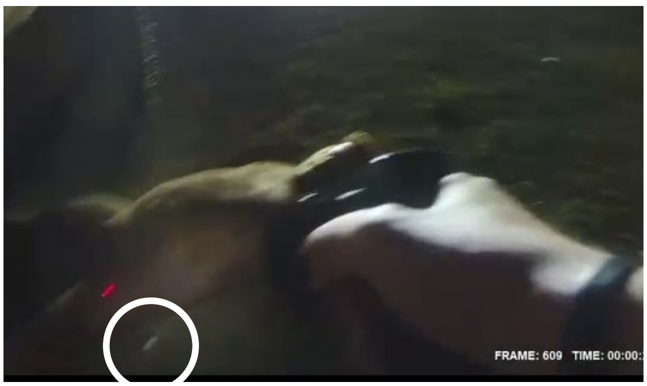

Figure 8. Taylor missed probe seen on ground at 23:59:14.

Taylor Deployment #2.

Taylor swapped in his spare cartridge at 23:59:14. At 24:00:12 Lakey stood quickly during Dingman's TP # 4 and Taylor deployed from the new cartridge. Lakey flinched from the ballistic impact and then slowly (over 1.8 seconds) went back down to the ground. Due to the small probe spread, no NMI was achieved which is seen by the fact that Lakey went down so slowly and was able to brace the fall with his right arm. With NMI, the subject is frozen in place and falls immediately without steps. Typically, with probes in the back of a standing person they fall backwards due the strong contractions in the legs and the rhomboid muscles.{Kroll, 2016 #8384} In this episode, Lakey took a few steps forward which demonstrates that there was no NMI. With a good probe spacing, probes on the upper right side of the body would also have contracted the right arm with a fist going in towards the abdomen. See Figure 9.

Figure 9. Lakey falling at 24:00:15

In my opinion, this fall was most likely caused by the disorientation from the surprise of the ballistic impact and the irritating cutaneous nociceptor stimulation. There was essentially no muscle stimulation and certainly no NMI.

Taylor's TP #5 thru #29 occasionally resulted in some yells but never any NMI. For example, during TP #6, #10, #20, and #25 Lakey complained but had good control of his body as evinced by his arm movements and ability to roll around. Sometime between TP #29 and #30, the connection was lost and lake he was able to jump to his knees during the simultaneous trigger pull of Taylor (#30) and Dingman's TP #23. See Figure 10.

Figure 10. Lakey getting up during simultaneous trigger pulls.

The speed of Lakey's movements during this dramatic action demonstrates that he was not exhausted with acidosis at this point.

It bears noting that officer Taylor was following the baseball tactical rule, which states that an officer should transition after 3 failed trigger pulls. In fact, Taylor did this after he realized that his first trigger pull had had no effect. Beyond that, he had no more spare cartridges so he had few reasonable options.

Dingman Deployment #1.

Dingmans 1st deployment was to the abdomen. As mentioned earlier, this deployment had no effect even though there was an electrical connection. Lakey complain but was able to roll over and demonstrated leg control. Sometime between TP #3 and TP #4, Lakey apparently pulled out the upper probe from the abdomen thus breaking the connection. TP #4 showed zero charge being delivered to the body ($Q = 0.9\ \mu C$ which indicates wires connected to the cartridge but not to anything else).

Dingman Deployment #2.

After recognizing that his connection had been broken, Dingman swapped in his spare cartridge at 24:00:29. He deployed this cartridge at 24:00:52 (TP #5).

A probe landed in the mid upper back as seen in the autopsy photo in Figure 5. Note that this probe is *not* seen after the successful restraint (see black & white insert of Figure 5). This probe likely dislodged when Lakey rolled over at 24:00:55.

Dingman's trigger pulls #6 thru #19 show low charge delivery (Q = 8.2 – 38.2 μC) consistent with probes in grass or soil. Trigger pulls #20 thru #23 show almost no charge delivery (Q = 1.2 – 1.3 μC) consistent with a wire becoming detached from a probe in grass or soil.

It bears noting that officer Dingman was substantially following the baseball tactical rule, which states that an officer should transition after 3 failed trigger pulls. Dingman did this after he realized that his first 4 trigger pulls had had no effect. Beyond that, he had no more spare cartridges, so he had limited reasonable options.

Deployment Summary

Table 7. Deployment Summary

Officer	Number	Probes in Body	Probes Effective?	Neuromuscular Incapacitation?
Taylor	1	1	N/A	No
	2	2	No. Poor spread	No
Dingman	1	2	No. Obese abdomen.	No
	2	1	N/A	No

Details of Opinions

1. Lakey Was Sitting Up 2 Minutes After the Last Current Delivery.

Mr. Lakey was sitting at 24:10:08 and the last current delivery was at 24:08:05 which was Taylor's TP #29. With an electrocution the pulse is lost instantly, and consciousness is lost within 13 seconds.[26,59]

The prolonged struggle after the last Probe-mode shock eliminates electrocution as a possible cause of death.

2. The Cardiac Arrest Occurred About 7.5 Minutes Later.

The last (probe-mode) shock ended at 24:08:05. Mr. Lakey's cardiac arrest was noted around 224:15:25 which was about 7.5 minutes later. With an electrocution the pulse is lost instantly, and consciousness is lost within 13 seconds.[26,59]

The delay to the cardiac arrest after the last probe-mode shock eliminates electrocution as a possible cause of death.

3. Mr. Lakey's Cardiac Arrest Presenting Rhythm Was Asystole.

Mr. Lakey's cardiac arrest rhythm were asystole (flat-line) and pulseless electrical activity (PEA). Asystole and PEA are the typical non-shockable cardiac arrest rhythms and are not inducible with electrical stimulation. [60-65] Electrically-induced VF will eventually deteriorate into asystole or PEA. Without chest-compressions, this takes over 30 minutes.[66] With CPR, the time for VF to deteriorate to asystole or PEA is even longer — around 60 minutes or more.[67]

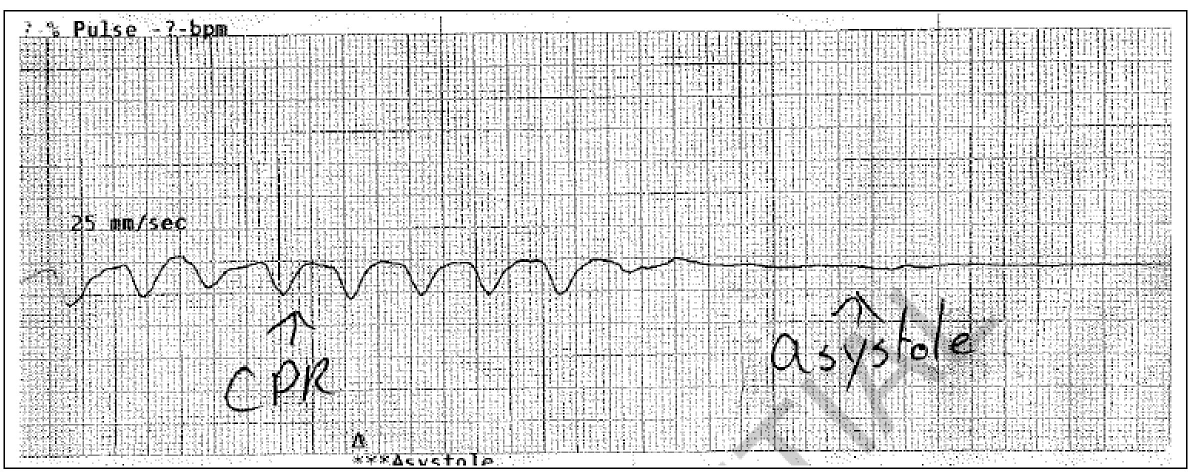

Figure 11. Asystole documented by paramedic McKee.

Asystole and PEA are the most common cardiac arrest rhythms in deaths associated with drug and alcohol abuse.[69-74 75-77] Asystole and PEA are the most com-

mon cardiac arrest rhythms in deaths associated with excited delirium syndrome.[78-88] They are also very common with sudden death due to heart disease.[89]

Mr. Lakey had the cardiac arrest presenting rhythm of asystole (flat-line), eliminates the possibility that he was electrocuted by the CEW.

4. No Probe was near Mr. Lakey's Heart

For a TASER® CEW, electrocution requires that the tip of a probe within 3 mm of the human heart. As seen in the autopsy photos, the closest probe was the upper abdominal probe and that was about 15 cm from the heart, or 50 times are required distance.

The closest probe was 50 times the required distance from Lakey's heart, and this eliminates the possibility that he was electrocuted by the CEW.

Materials Reviewed or Considered:

Videos
- Officer Body Worn Cameras
- Merged Video with BWCs and Dash Camera.

CEW Downloads
- Bryan Chiles Report

Police Reports:
- Investigators Reports
- OSBI Primary Report
- Officer Interviews

EMS Run Sheet

Criminal Trial Transcript

Expert Reports
- Mr. Leonesio
- Dr. Sperry
- Mr. DeFoe
- Dr. Hail
- Capt. Meyers

Benefits and Risks of Electronic Control

Electronic control benefits are well-established in the peer-reviewed literature and explain why these weapons are so widely adopted throughout the industrialized world (107 countries). Subject injury rates are cut by ≈ 2/3. The MacDonald study covered 12 USA law enforcement agencies and 24,380 uses of force.[39] They found that the CEW reduced subject injury by 65%. Taylor et al analyzed data from 13 USA agencies including 16,918 uses of force and described a 78% reduction in injuries requiring medical attention.[40] In other words, the use of alternative force options, including hands-on physical force, tends to *at least* triple (3x) the injury rate compared to the CEW. [39,40]

The number of law enforcement firearms shootings prevented has been estimated at over 220,000 based on the 4.1 million CEW field uses.[90,91] In agencies using the CEW with minimal restrictions, the fatal officer shooting rate falls by ≈ 2/3.[42] The overall reduction in the ARD (arrest-related-death) rate is 59-66%.[92]

Table 8. Primary risks from CEW probe-mode applications.

Risk	Findings	Notes
Primary (Direct) Risks		
Electrocution	Theoretical possibility with fully embedded dart directly over heart in subjects under 46 lbs.[93] In general, electrocution events in adults is an urban legend.[94-96]	Present CEWs satisfy all world electrical safety standards.
Loss of vision	Demonstrated with probe penetrating the eye.[97-100]	
Primary Secondary (Indirect) Risks		
Head injury from fall.	Fatalities demonstrated.[101] Non-fatal injuries demonstrated.[102,103]	
Fume ignition.	Fatalities demonstrated.[104,105]	

The primary demonstrated and theoretical risks supported by the existing literature are outlined in Table 8. The most common contribution to fatality is a secondary injury from a head impact from an uncontrolled fall. If the subject is running or above a hard or elevated surface, and receives a CEW probe deployment, the unbroken fall can sometimes result in a serious head injury and there have been 16 deaths due to this.[101] This has not been reported with the drive (or contact or touch)-stun mode as there is no muscle lock-up. There have been 8 secondary fatalities in which flammable fumes were ignited by an electrical spark from the CEW.[92,104,105] This has not been reported with drive (or contact or touch)-stuns although that remains a theoretical possibility.

The most misunderstood and exaggerated theoretical risk is that of electrocution. This is extremely unlikely as the output of existing CEWs satisfy all relevant world electrical safety and effectiveness standards including those for the ubiquitous electric fence.[44,45,47,50] The conservative IEC (International Electrotechnical Commission) standard allows up to 2.5 W (watts) for an electric

fence and all present TASER CEWs deliver less than 2 W.[48] Underwriters Laboratories (UL) allows 5 W for narrow pulses such as those of TASER CEWs.[49] The primary driver of this myth appears to be the fundraising material of Amnesty International, and some sensationalistic media, that lists Arrest-Related Deaths (ARDs) along with the innuendo that the CEW somehow electrocuted the subject. Notably, they have never attempted to explain how a CEW that satisfies all electrical safety standards could ever electrocute anyone.

Swine are 3 times as sensitive to electrical current as humans.[106] The largest swine electrocuted by an X26E CEW was that of Valentino with a 10-second CEW discharge and it weighed 36 kg (79 lb.).[107] Nanthakumar also electrocuted a *single* 50 kg swine with a 15 second CEW discharge but he used a drug trick which made the swine's weight equivalent to ≈ 30 kg.[108] Hence the largest swine ever electrocuted by a CEW weighed only 36 kg.

The levels of dangerous electrical current scale with body mass just like a drug dosage. Since swine are 3 times as sensitive to electrical current (as humans) this is translated to the single Valentino 36 kg pig to a 12 kg (26 lb.) human.[106] This calculation uses a direct-proportion relationship of dangerous current levels to the body mass. Some authorities have published that the danger level scales with the square root of body mass.[109] With such a relationship the Valentino pig is equivalent to a larger 21 kg (46 lb) human. Taking the more conservative calculation, the best evidence suggests that the risk of CEW electrocution is limited to humans weighing less than 46 lbs.

Most authorities agree that electrocution is a theoretical possibility with an extremely thin individual and a fully penetrated dart directly over the heart in a very thin person with a very small dart-to-heart distance (DTH).[110-112]

Table 9. Summary of benefits and risks of CEWs.

	Item	Rate
Benefits:	Subject injury	2/3 reduction
	Subject death	2/3 reduction
Risks:	Fatal fall	1:200,000
	Fatal or nonfatal major burn	1:360,000
	Blindness from dart	1:200,000

The very rare risks of CEW complications are swamped by the lives saved and serious injuries minimized from the reductions of ARDs. For every ARD from a CEW complication (fatal fall or fire) there are 50 ARDs prevented by reducing firearm shootings and over-exertional deaths. Additionally, there is 1 temporal ARD for every 1,000 traditional uses of force, or 1 temporal ARD for every 3,500 uses of CEWs.[92,101]

Major Myths

Because electricity is invisible and potentially dangerous (at high currents) there is widespread fear and misunderstanding of it among the public and the legal profession. See ***A. The Electrophobia Myth*** at page 44 of this report. Due to unscientific media sensationalism and litigation, this has contributed to some widespread urban myths surrounding electrical weapons.

It may prove helpful to discuss some of these myths before delving into greater details of this incident.

Myth #1. People Have Been Electrocuted by an Electrical Weapon.

Speculations of electrocution by a handheld electrical weapon should be viewed with great skepticism since these weapons satisfy all relevant USA and international electrical safety standards. (The single exception is the Brazilian Condor® Spark which satisfies the Underwriters Laboratory but not the European electric fence power limits.)

Numerous swine and human studies suggest that the risk of CEW electrocution is limited to humans weighing less than 21 kg (46 lbs.) and requires a perfect fully-penetrated probe directly over the heart.[107,110,113] A major driver of this electrocution myth was the Zipes-Burton case series. John Burton is a lawyer specializing in suing law enforcement and Dr. Douglas Zipes was his expert witness. They published summaries of their 8 CEW cases in 2012.[114] It was full of errors including a case where the CEW probes missed the subject. Later the journal, *Circulation*, required Dr. Zipes to acknowledge Mr. Burton as his co-author and to admit that they had mischaracterized the subjects as "clinically normal."

In addition, the Zipes-Burton case series was analyzed by the Canadian Council of Science.[94] Their peer-reviewed report (Oct 2013) was produced by a deliberative panel that included numerous Canadian and USA experts on electrical weapons and arrest-related death (ARD) and was extensively peer-reviewed. This panel dismissed the Zipes-Burton case series.[114] The Canadian Council report was very direct:

> The study by Zipes is particularly questionable since the author had a potential conflict of interest and used eight isolated and controversial cases as part of the analysis.

In 2013 the journal, *Circulation*, invited me to submit a refutation which I did with 2 cardiologists and a cardiac pathologist. This was published Jan 2014 so the Zipes-Burton paper has been refuted for already 7 years.[115]

Myth #2. The AHA did a Study Proving Electrocution

Since the journal *Circulation* is published by the AHA (American Heart Association), the above myth sometimes appears in a more dramatic fashion: "The American Heart Association did a study proving that 'tasers' can electrocute."

Myth #3. The Baseball Rule has a Scientific Basis.

Many law enforcement agencies have policies and guidelines limiting officers to 3 trigger pulls (or 15 seconds) and this is generally referred to as the "baseball rule" in analogy to the 3-strikes allowed in that game. While I do not give legal opinions, I do understand that there are decisions ruling that each trigger pull, just like each strike with a baton, fist, or foot, and each exposure to OC spray is a distinct use of force which must be legally acceptable and thus in some instances there is legal rationale supporting something like the baseball rule. Ironically, no agencies limit their officers to 3 rounds in their firearms, 3 baton strikes, 3 OC spray squirts, 3 strikes with a physical weapon, or 3 arm bars.

This guideline is often taught as a "transition rule" teaching that officers should consider force-option transition to a *different* control technique if 3 CEW trigger pulls do not suffice in accomplishing the officer's force objective. That dogma is questionable as the most appropriate *different* transition tool would be the firearm since the electrical weapon is the most effective intermediate force option.[39,40] A transition to pain-compliance tools, such as chemical agents, impact tools, or impact projectiles would not be helpful as they are generally less effective on subjects in the throes of a mind-body disconnect.

Well over 100 years of electrical research has demonstrated that the effects of electricity do not build up like poison. Specifically, the USA military has tested this in swine with continuous CEW exposures across the chest for up to 30 minutes — not 30 seconds.[116] If someone is electrocuted this generally occurs within 1 second with an upper limit of ≈ 2–5 seconds.[26,36,117,118] If an electrical current is strong enough to kill someone it will do so in the first few seconds of exposure and a longer exposure duration simply has no additional effect. There is no increased danger in going from 5 seconds of electrical current to 50 seconds. The US FDA approves much stronger muscle stimulation for 20 minutes.[3-5] See ***The Dogma Of 3 Strikes And 15 Seconds***at page 52.

A scientifically-supported CEW transition rule would be as follows:

1. The officer should note if their CEW is failing to incapacitate the subject. This is typically noted in a few seconds — not 15 seconds.
2. The officer should transition to a different CEW cartridge and redeploy since the primary reason for lack of incapacitation performance is a bad connection.

Current model CEWs, such as the X2 and the T7 CEWs, hold 2 cartridges and thus this transition issue is minimized. If the officer does not achieve sufficient incapacitation, they can simply pull the CEW trigger again and deploy a 2nd pair of probes so the "transition" rule becomes obsolete.

There is no scientific basis to the baseball rule.

Myth #4. Simultaneous Trigger-Pulls are More Dangerous.

Due to the numerous potential limitations of electrical weapons, such as small probe-spreads, broken wires, missing probes, and clothing disconnects, officers may need to provide a back-up simultaneous deployment — especially in an urgent situation or where the subject is reasonably perceived as a significant immediate threat. In fact, current model CEWs such as the X2 and the T7 CEWs, hold 4 probes and thus this can be done by a single officer. I.e. a single officer can now easily deliver "simultaneous" currents into a subject.

As a practical matter, true simultaneous current delivery almost never occurs as the reason for a backup deployment is usually the failure of the primary deployment. The cardiac, breathing and biomarker effects of simultaneous CEW discharges has been extensively studied. The application of 2 and 3 simultaneous discharges (4 and 6 contacts) into human volunteers was tested a decade ago and no deleterious effects were noted.[14,119] Other studies have tested 10-second continuous exposures with up to 4 probes (2 simultaneous discharges) without ill effects.[15,120] Nevertheless, this obsolete rule persists in many agencies even though the current model electrical weapons make it, for all practical purposes, irrelevant.

Myth #5. The Heart is a Muscle, so it is Affected Like Skeletal Muscles

This is an older myth that has largely died out with the numerous animal and human studies published in the last decade. The basic message is the innuendo that electrical weapons must be able to electrocute (i.e. stop the heart) since they stimulate the skeletal muscles. It is easily dealt with by noting:

1. Skeletal muscles are on the outside of the body while the heart is on the inside of the body.
2. Electrical current tends to follow the grain of the muscles and thus it mostly stays within the skeletal muscles and does not dive down to the internal organs.[121-123]
3. Skeletal muscles are controlled by nerves coming from the spinal cord while the heart provides its own stimulation.[124-126]

A Brief Primer on Electrocution.

Low-power electrocution is death from an electrical current from a source under 1000 watts (W).[127] This is contrasted from "high-power" electrocution from power lines or lightning strikes. The death is almost always the result of the electrical current inducing VF (ventricular fibrillation). The electrical induction of VF takes a few seconds at most.[31-37,117,118,128-130] (A massive electrical injury from a lightning strike or powerline can also cause death by nervous-system damage or kidney failure but that is not relevant here.) Modern CEWs fall in the "low-power" category. The TASER® CEWs all deliver ≤ 1.8 W.

In VF, the heart muscle cells continue to contract but at nearly random times. This is a common cause of cardiac arrest. Hence, there is no coordination among the cells and no blood is pumped from the heart. Loss of consciousness occurs in 13 ± 4 seconds if the person is supine (laying down).[59] If someone is standing or sitting then the collapse occurs within 1-5 seconds.[131,132] Also, the person loses their pulse immediately. Once VF is induced, there is no pulse. There are 6 primary diagnostic criteria required to diagnose an electrocution as shown in Table 10.

Table 10. Primary diagnostic criteria for electrocution.

#	Criterion	Timing
1	Sufficient current delivered to heart.	1-5 seconds of duration. [130] See Background section: *Electricity Does Not Build Up Like Poison.*
2	Loss of pulse.	Instant[133]
3	Loss of consciousness.	13 seconds if laying down.[59] 5 seconds if sitting up.[59,131,132]
4	Loss of normal breathing.	15-60 seconds.[133,134] Agonal breathing (typically 3 minutes) with a maximum of 6 minutes.[134-136]
5	Successful defibrillation.	14 minutes with any cardiopulmonary resuscitation (CPR); 9.5 minutes without.[137]
6	VF rhythm.	30-40 minutes after which the VF typically deteriorates to asystole or PEA.[66,138-141]

A final note on electrocution is that it is a stand-alone cause of death. Electrocution is not like a soup recipe where salt and pepper both contribute to the flavor. It does not "contribute" to other causes of death.[18] For example, if someone with late-stage cancer were to receive sufficient current, they would be dead within seconds and the cancer had nothing to do with it. However, if the same person received a lower level of current and died 30 days later, that person was not electrocuted. People have died as a result of falls from ladders after being startled by an electrical shock. The shock was certainly temporally related to the death, but this is not an electrocution as the fall from the ladder was secondary to the electrical shock. With rare partial exceptions — generally not salient to ARDs — the presence of other disease states does not make someone significantly harder or easier to electrocute. Conversely, low-power electrical currents do not hasten deaths from other diseases.

The CEW has an insignificant effect on a subject's adrenergic and metabolic state.[13,15,16,142-146] However, the effects of metabolic and adrenergic stress on the electrocution threshold have also been extensively studied. The effects, while statistically measurable, are immaterial in the ARD scenario. Adrenergic stress will temporarily lower the VF threshold (VFT) for a few minutes after which the VFT increases.[147,148] The impact for electrical weapons is that the critical dart-to-heart distance (DTH) could increase temporarily to 4-5 mm. Metabolic acidosis also has a similar immaterial effect.[149] Cocaine, a sodium channel blocker, *increases* the VFT and hence makes electrocution even more difficult.[150,151]

Blood has a typical resistivity of 150 Ω•cm and is thus the best electrical conductor in the body along with skeletal muscle (with the grain).[127,152,153]

Misunderstanding the Trigger-pull Download

A common error is to assume that the "TASER" data download in any way represents current delivery to the subject. It does not. It represents only an upper bound on the seconds of current discharged. The total time given by the download is typically 2-3 times what the actual total duration of current delivery was. This is theoretically harmless as the total duration of current is essentially irrelevant to diagnostics since electricity does not build up like poison. Thus, the most exaggerated figures are often the least relevant. However, novice CEW "experts" often stress the total trigger-pull time so it should be addressed.

A TASER download printout showing trigger pull times with a total of, say, 100 seconds provides the following information:

- The times of the trigger pulls (after clock-drift correction).
- The number of seconds of current delivery is 0-100. I.e. somewhere between 0 and 100 seconds.

As an example, in the tragic death of the methamphetamine addict, Robert Heston, (who attacked his father and father's home) there were a total of 206 seconds of trigger-pulls on 5 M26™ CEWs and 6 deployed cartridges used to attempt to control him.[154] A careful analysis found that the actual duration of current delivery was 5-9 seconds. Here the exaggeration was at least 20:1. In a non-USA case (unnamed here due to confidentiality restrictions) there was a total of 154 seconds of trigger-pull duration from 28 trigger pulls. Each CEW had a camera attached and thus the actual duration of current delivery could be determined from an audio analysis.[155] There was a total of only 20 seconds of current delivered.

U.S. Federal Appeals Court decisions recognize that trigger pull records do not equate to delivered current. See *Hoyt v. Cooks*, 672 F.3d 972, 976 (11th Cir. 2012)("The record shows that an 'activation' of the Taser does not mean that the Taser actually touched or stunned Allen."). See also *Bussey-Morice v. Gomez*, 587 F. App'x 621, 625 (11th Cir. 2014):

> the report further notes that in order for energy to be transferred from the Taser via the probes, contact must be made with the individual by both probes to complete the circuit…The TASER log shows only device activation; it does not represent that a shock was actually delivered to a body nor does it distinguish between probe deployment and drive stun.

Causes of Current Delivery Exaggeration:

1. Broken wires or dislodged probes
2. Rounding up to the next second
3. Muzzle contact canting with drive-stuns
4. Muzzle contact and release delays
5. Inadvertent trigger pulls

Broken Wires or Dislodged Darts

A significant reason for multiple or prolonged CEW trigger pulls is that the fragile wires are broken early in the encounter and the officer continues to pull the trigger, hoping for a restraint-helpful response from the subject.

The tiny wires (36 gauge, 127 microns in diameter) are about the diameter of some human hair and are usually quickly broken during any struggle and are typically broken when a subject turns, falls, or flails his arms. The tensile strength, of the wires, is weaker (less than 1 kg) than the weakest fishing line (2 kg or 4 lbs breaking test) and are thus very easily snapped.[156] In fact, in some instances prisoners now teach other inmates that they should roll over if they receive a CEW discharge, in order to break the wires.

Probes are also often lodged in the clothing instead of the skin.

Rounding Up to the Next Second

The reported trigger-pull durations, in the TASER CEW download reports, are rounded up from the first 1/100 of a second. I.e. if the actual duration was 2.01 seconds then it is reported in the download as 3 seconds. Thus, the best estimate of the actual trigger pull is ½ second less than what is reported. Automatic duration trigger pulls of 5 seconds are, in fact, 5.00 seconds and thus there is less risk of an interpretation error there. This is irrelevant with the Trilogy "Pulse-logs" which give trigger pull and arc-switch durations to the nearest 0.1 second, and report each pulse.

Muzzle Contact Canting with Drive-stuns

As seen in Figure 12, an effective drive-stun application requires that the CEW muzzle be kept nearly perpendicular to the body surface. This can be difficult to do with a moving subject. A non-analgized non-anesthetized subject will reflexively pull or roll away from the attempted shock. On average, a good contact is only made about 30% of the time. If the muzzle is canted up to 20° away from perpendicular, then an arcing connection can still be made. The typical correction is to subtract 70% from the download times.

Muzzle Contact and Release Delays

With a drive-stun the officer will typically pull the trigger as the muzzle is being brought down towards the subject. The results in the trigger-pull duration overstating the current delivery by about ½ second. If the officer is delivering a drive-stun of less than 5 seconds, they will usually need to pull the weapon back to more easily activate the safety and this release delay also results in the trigger-pull duration overstating the current delivery by about ½ second. In total, the contact and release delays add about 1 second to the actual current delivery time for drive-stuns.

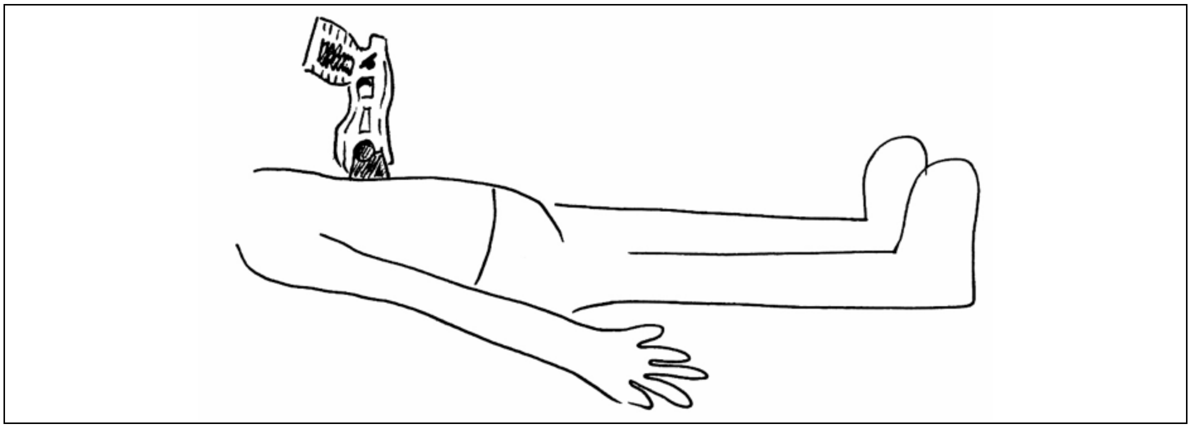

Figure 12. The drive-stun requires that the CEW muzzle be kept nearly perpendicular.

Inadvertent Trigger Pulls

Background:

The inadvertent trigger pull (ITP) has been well studied for firearms discharges.[157,158] According to Heim there appear to be 3 primary causes:[157]

1. sudden loss of balance;
2. contractions in the hand holding the weapon while other limbs are in use, for example during a struggle with a suspect;
3. startle reaction.

Common to every incident, in addition to the weapon being held in a hand, is that all limbs appear to be involved in the resulting sudden movement.[157] Recent work by the Lewinski group found no cases of firearm ITPs involving startle.[159] We have also not seen situations where a startle reaction led to a CEW ITP and thus we will focus on #1 and #2 above. Another potential cause is the *fist* reflex which is natural from birth and can be reinforced by training with closed-hand strikes; this can occur in a high stress confrontational situation.[160,161] The fist reflex may not apply to CEW ITPs and will not be discussed further here.

Physiology:

It has been recognized for over 100 years that muscle contractions in any limb can lead to increased activity in other limbs.[162] This has generally been referred to as *motor overflow* or *overflow activity*.[163,164] This is especially seen in opposite (contralateral) limbs where the phenomenon is referred to as *mirror movement*.[165-168]

When we contract a *single* hand firmly we also *invariably* contract the opposite hand somewhat.[169] Typical male grip strength is 130 ± 16 pounds where 25- 42% is exerted by the index finger.[170] Overflow activity can reach a maximum of 25% of the maximum voluntary force of the individual limb.[171] Thus, forces of up to 14 pounds (= 25% • 42% • 130 lbs.) can be involuntarily exerted by the index finger.[157] This is sufficient to overcome the trigger pull (8-

12 lbs.) for the 1st round of an uncocked double-action pistol. Even when warned to keep their fingers off of the trigger — and knowing that they were being studied — 21% of officers contacted the trigger for > 1 second in stress simulations.[157] When studied with their index finger already on the trigger, 28% (=7/25) of volunteers gave involuntary trigger pulls of > 14 lbs. when they either pulled with their opposite arm or lost their balance.[157]

Effect of Officer Age:

Shinohara studied the contralateral hand contraction in 10 young (18-32 yo) and 10 old (66-80 yo) right-handed subjects.[173] For young people, the contralateral force was greater when the right (dominant) hand was voluntarily activated. For old people, there was no statistically significant difference between the hands. As seen in Table 4, the strongest mirror index finger force was in older subjects; the weakest was in the right hand of the young subjects. Due to the mechanical restrictions imposed on both hands, the MVC (Maximum Voluntary Contraction) was < 20% of what can be measured on an unrestricted hand and arm.[174] Force is given in newtons (N).

Table 11. Shinohara contralateral index finger contractions.

Subjects	Hand	MVC (N)	Involuntary	Involuntary
Young	Right	25.8	4.7%	1.21
Young	Left	25.5	9.1%	2.33
Old	Right	29.9	13.8%	4.13
Old	Left	27.6	11.4%	3.15

Shinohara concluded, "The results indicate that old subjects have a reduced ability to suppress unintended contralateral activity." This is clearly seen in Figure 13.

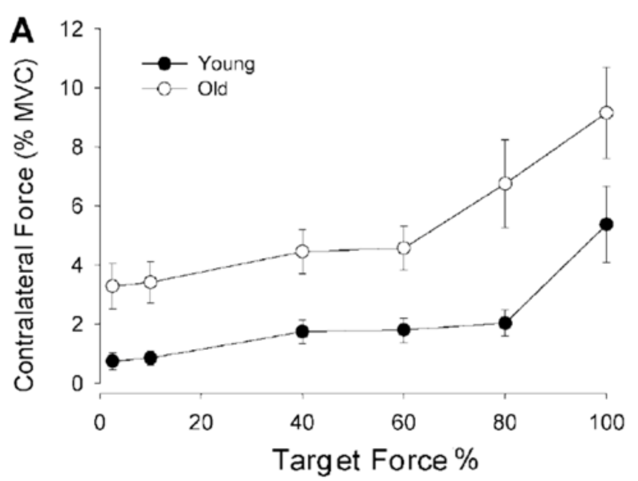

Figure 13. Shinohara study showing increased contralateral activity in older subjects.

The combination of involuntary muscle contraction activity and a finger on the trigger (which was either unconsciously pre-positioned or moved with the involuntary activity) is responsible for many inadvertent firearm discharges by law enforcement officers.[158,159,172]

Comparison to Firearms:

With the conducted electrical weapon (CEW), the incidence of ITPs is far greater — than with firearms — for 2 primary reasons:

1. The CEW trigger pull is far less at only 2 lbs. for the popular X26 (X26E) CEW and 3 lbs for the X2 CEW. The trigger is thus 3-6 times more sensitive than that of an uncocked double-action pistol.
2. Officers commonly hold the CEW in their dominant hand and attempt to assist with subject control or lifting with the other hand. They would never do this with a firearm as it is forbidden by weapons retention training.

Ironically, the situation is both far worse but also far better for the CEW compared to the firearm. While a CEW operator will have far more ITPs, the results are almost always harmless compared to the often-fatal consequences of a firearm ITP.

The Harm of the Helping Hand:

A major cause of mirror-movement ITPs is an officer trying to help control a subject with the non-dominant hand while keeping the CEW in the dominant hand. In a helping hand scenario, at least 2/3 of the trigger pulls are ITPs.

We have investigated many incidents in which the *majority* of trigger pulls appear to be ITPs. In the typical case the officer is maintaining his grip on the weapon while trying to restrain the subject with the free hand and possibly also the CEW-constrained hand. This can also occur while holstering the weapon if the opposite hand is being engaged in the struggle. Thus, during a physical struggle with the CEW in an officer's hand, most of the CEW discharges tend to be mirror-movement ITPs which then run the full standard default 5 seconds or until, or if, the officer realizes what is happening (from the arcing sound) and turns the weapon OFF (safety ON). In many cases, the arcing sound is not noticed because of the yelling, environmental noise, or the focus on a struggle.

Incidents with multiple (>3) trigger pulls and full documentation (Trilogy pulse-logs and body-cameras) have been analyzed to determine the relationship between the trigger pull time-totals and the actual seconds of current delivered. The interesting finding is that the actual seconds of current begins to level off at 10-15 s so the percentage of time continues to decrease from ~35% down to as low as 5%.

Most of the CEW ITPs occur with drive-stuns which are well established as having no deleterious effects outside of short-term minor contact burns.[173-]

[175] Moreover, the inadvertent drive-stun trigger pull is almost always with the weapon far away from the subject as the officer's opposite hand is the one in contact with the subject. For the minority of cases that began as a probe-mode deployment, the connection has usually been broken by the grounding, attempted restraint, or ground struggle. If a full probe connection was still existing, then there would be far less need for manual control and hence a low likelihood of an ITP.

Forensic Evidence

After 2 seconds of drive-stunning through clothing, small sunburn-like marks will be left. A drive-stun leaves a pair of distinctive marks due to the 40 mm fixed distance between the muzzle electrodes.[175] This is depicted in Figure 14.

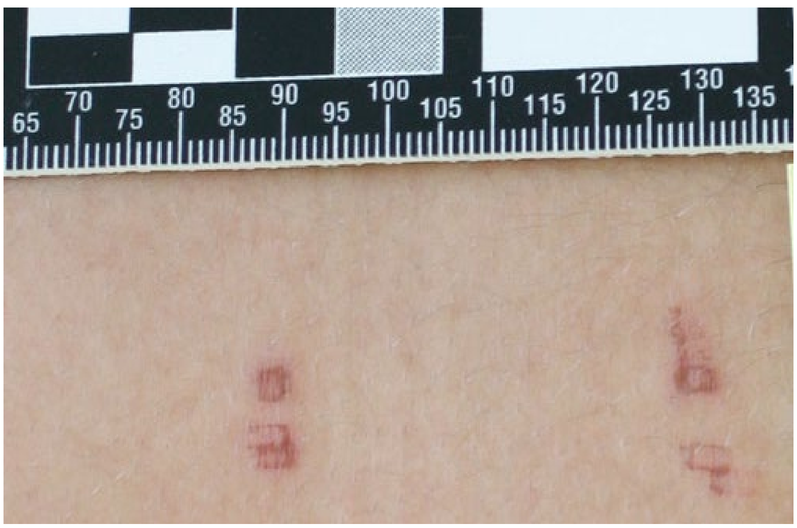

Figure 14. Drive-stun marks.

For probe-mode applications, microscopic analysis of the "eye of the needle" in the back of the probe can estimate the duration of the current delivery.[176,177]

The newer model CEWs, X2, X26P, and T7 allow the duration determination from the enhanced "Pulse Log" download.

The Significance of the Sound

The X26E CEW is fairly quiet at 51 decibels (dBA) @ 1 meter, when it has a completed circuit connection. The X26E is much louder when it is arcing and *not* completing a circuit (79 dBA @ 1 m). This is like many devices that are quiet when working properly and louder when not. Sound levels from ordinary sources as seen in Table 12.

The scientific basis of the crackling sound emitted from an electrical arc has been well studied.[178-180] This distinction is also known to CEW-trained law enforcement officers, and easily demonstrated in many ways such as arcing to a soda can or across the CEW muzzle.

Table 12. Sampling of sound levels from various sources.

Sound level (dBA @ 1 m)	Source
90	Train whistle (@ 150 m)
79	X26E CEW open-circuit crackling
70	vacuum cleaner
60	polite conversational speech
51	X26E CEW closed-circuit clicking
50	average home volume, normal refrigerator
40	quiet library
30	quiet bedroom at night

There is indeed a dramatic difference between the open circuit arcing and intact circuit sound level. When the X26E CEW is deployed with a completed circuit (such as contacting a body) it makes a relatively soft clicking noise which is softer than normal conversation and on the order of the sound from a properly operating refrigerator. However, in the open-circuit mode — such as when a wire is broken, a probe misses, there is a clothing disconnect, intermittent disconnect, or a probe is dislodged — the sound level is 79 dBA which is well above that of a vacuum cleaner. The difference between 51 dBA and 79 dBA is logarithmic and actually corresponds to a ratio of:

$$\begin{aligned}\text{Ratio} &= 10^{((79-51)/10)} \\ &= 10^{2.8} \\ &= 631\end{aligned}$$

Thus, the X26E CEW in arcing mode has 631 times the sound *intensity*. This arcing sound is heard with a spark test. With a closed circuit (good connection) the sound cannot be easily heard over loud conversation and generally not over yelling and shouting. The arcing (open-circuit) sound is not only much louder but has a *different* sound. It is often described as a "crackling" sound as opposed to a "clicking" sound. The "crackling" sound is so different that it can be easily differentiated by zooming in on the sound recording as depicted in Figure 15. The top tracing is the instantaneous sound level of an X26E CEW that is

arcing (at the muzzle) while the lower tracing is of an X26E CEW with an intact circuit. Note that 3 pulses are shown in each tracing. The X26E CEW discharges at a pulse rate of ≈ 18.3 PPS (Pulses Per Second) so the pulses are about 55 ms (milliseconds) apart. Note that the top (arcing) tracing intuitively appears "noisier" — which it is. The lower tracing of the connected intact completed circuit "clicking" sounds shows that they are much "cleaner."

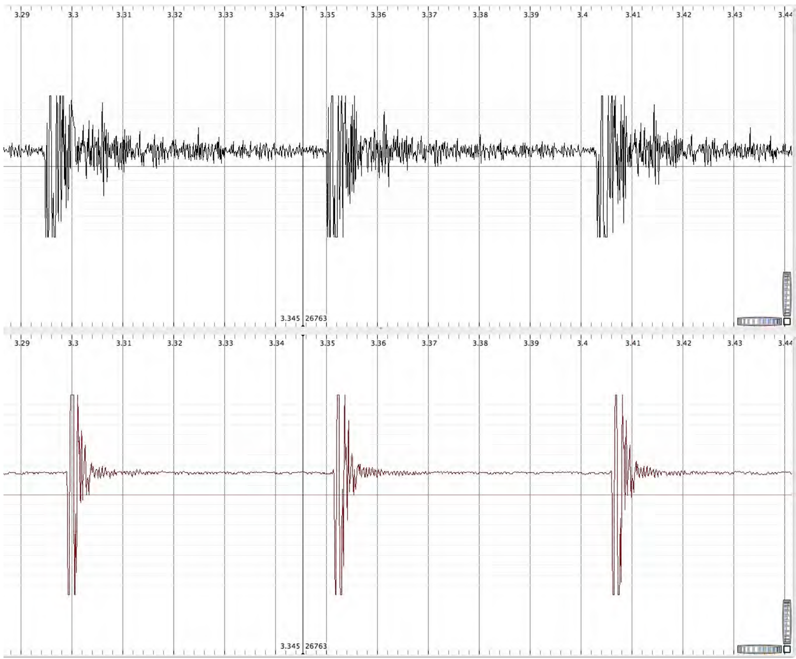

Figure 15. X26E CEW sound signatures of open circuit and closed circuit pulses.

The excursions of the sound level signal saturate the TASER CAM storage until the AGC (Automatic Gain Control) can automatically "lower the volume." That is why the louder crackling sound actually appears shorter in height. For a good connection, these excursions last about 2 ms as seen in the lower trace. For arcing, these excursions last ≈ 4 ms as seen in the upper trace.

General Background:

A. The Electrophobia Myth

Many people have an illogical emotional fear of electricity or *electrophobia*. From an early age in life it is drilled into young children that 110 V (volt) electrical outlets cause death, Thus, most people have deeply absorbed the urban myths that voltage itself is dangerous and 110 V causes death. While most people learned to dispel this myth in middle-school sciences classes it is often forgotten by adulthood. While this is scientifically incorrect most people, including most media, hold these myths to be undeniable truths.

Life itself could not exist without electricity. Trying to say that all electricity is dangerous is equivalent to saying that all balls are dangerous. There are marked differences in the effects of being struck by a ping-pong ball, baseball, bowling ball, and wrecking ball.

Table 13. AC Currents and Their Typical Effects

AC Current (mA)	Effect
1500	Nerve Damage
1000	
500	Cardiac Arrest Probable
200	
100	Cardiac Arrest Possible
50	Interference w Breathing
18	TASER ® Weapon (AC Equivalent)
16	Male No-let-go threshold
10	Muscle Contractions Begin
5	Pain Sensation
1.1	Male Hand Perception
0.7	Female Hand Perception

The typical effects of various AC currents are shown in Table 13. The < 2 mA of pulsed DC current (for the TASER® CEWs) is not directly comparable so a 18 mA AC equivalent is used.[181]

B. CEW Probe Mode

In probe mode, the TASER® handheld CEW uses compressed nitrogen to deploy 2 small probes at typical distances of up to 7.7 m (meters) or 25 feet.[182,183] (Other cartridge models can reach a distance of 11 m or 35 feet.) When the CEW trigger is pulled, the high voltage pulse first serves to activate a primer which opens the nitrogen cartridges to release the nitrogen to propel the probes as directed. These probes themselves are designed to pierce or become lodged in most light clothing (and to complete the circuit with the 50 kV arcing capability). The sharp portion of the probe is 9-13 mm (millimeters) long and will typically penetrate the epidermis and dermis to a depth of ~6 mm for a good electrical connection.

The ultra-short duration electrical pulses applied by TASER CEWs are intended to stimulate Type A-α motor neurons, which are the nerves that control skeletal muscle contraction, but without a high-risk of stimulating cardiac muscle. This typically leads to a loss of regional muscle control and a fall to the ground to end a violent confrontation or suicide attempt.

Small swine of 30 kg (65 lbs) can be put into VF when the CEW probes are put within a few mm of the heart. [107,184] One study used a custom long plunging probe to deliver the CEW current almost directly (within 6 mm) to the heart of a pig in order to induce VF.[185] There are numerous problems with the swine model that significantly exaggerate the electrocution risk. [184,186] Pigs are extremely sensitive to electrical currents due to their hearts being literally wired "outside-in" compared to a human's (being wired "inside-out").[187-192] The swine heart needs 2/3 less current to induce VF (ventricular fibrillation) compared to the human heart from external stimulation. In other words, the swine is 3 times as sensitive to electrocution as is the human.[193] This CEW-electrocution effect is also confined to *small* swine.[112] In stark contrast, human studies consistently demonstrate no risk of VF with a CEW application.[194-198]

This is clearly the consensus of the scientific and medical community as shown by various position papers. For example: the June 2009 American Medical Association (AMA) White (Position) Paper concluded:[199]

> Furthermore, no evidence of dysrhythmia or myocardial ischemia is apparent, even when the barbs are positioned on the thorax and cardiac apex.

On May 24, 2011, the National Institute of Justice, after a 5-year panel review, concluded:[200]

> Current research does not support a substantially increased risk of cardiac arrhythmia in field situations, even if the CED darts strike the front of the chest. There is currently no medical evidence that CEDs pose a significant risk for induced cardiac dysrhythmia in humans when deployed reasonably.

Finally, in June 2012, Bozeman stated:[197]

> The risk of such dysrhythmias, even in the presence of a transcardiac CEW discharge, is low, and suggest that policies restricting anterior thoracic discharges of CEWs based on cardiac safety concerns are unnecessary.

No danger or harm has been associated with the CEW probe-mode application, in human studies.

C. CEW Drive Stun Mode: Skin Rub vs. Injection

Alternatively, the CEW may be used in a "drive-stun" mode by pushing the front of the weapon into the skin to function as a higher charge stun-gun. With the fixed electrodes, only 4 cm (centimeters) or 1.6 inches apart — and the lack of skin penetration — the current flow is primarily through the dermis and fat layer between the electrodes and there is no significant penetration beyond

the subdermal (or subcutaneous) fat layer. See Figure 16. Since there is insufficient depth of current flow to capture muscles, the drive-stun mode serves only as a compliance technique. To make an analogy to medicine, drive-stun is like rubbing an ointment on the skin compared to the probe mode, which is like an injection. They have significantly different effects.

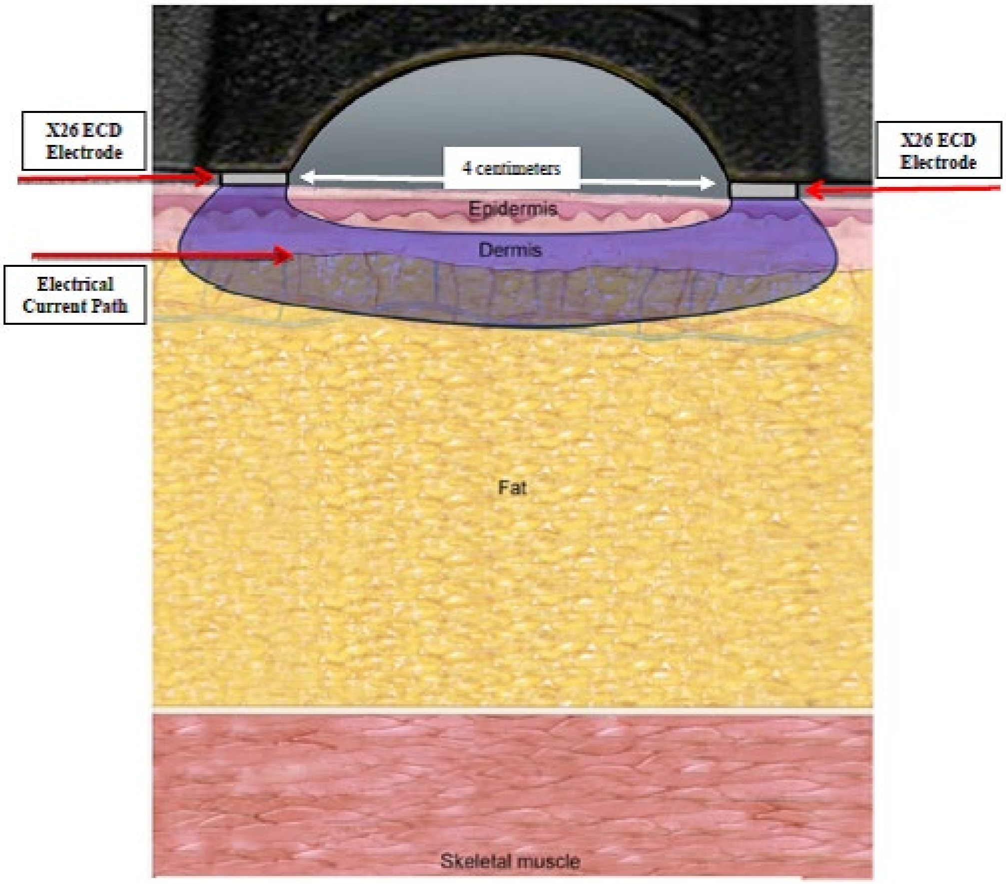

Figure 16. The majority of the drive-stun current is confined to the fat and dermis layer.

As mentioned above, small swine (30 kg or 65 lbs) can occasionally be put into VF when fully-embedded CEW *probes* are nearly touching the heart.[201,202] *However, it is impossible to fibrillate even small swine with a transcutaneous CEW drive-stun application.*[203-206] The electrical current simply does not penetrate deeply enough to affect any human muscles or organs. In fact, with a CEW drive-stun application directly over the human phrenic nerves (the nerves that control breathing) there is no effect.[207]

The National Institute of Justice, 5-year study of CEWs, found:[200]

> Risk of ventricular dysrhythmias is exceedingly low in the drive-stun mode of CEDs because the density of the current in the tissue is much lower in this mode.

The American Academy of Emergency Medicine (AAEM) has the following guideline on drive-stun applications:[208]

> For patients who have undergone drive stun or touch stun ECD exposure, medical screening should focus on local skin effects at the exposure site, which may include local skin irritation or minor contact Allen. This recommendation is based on a literature review in which thousands of volunteers and individuals in police custody have had drive stun ECDs used with no untoward effects beyond local skin effects.

The Federal Court of Appeals for the 9^{th} Circuit [*Brooks v Seattle*], and others, have concluded:

> The [TASER CEW]'s use in "touch" or "drive-stun" ... involves touching the [TASER CEW] to the body and causes temporary, localized pain only. ... this usage was considered a Level 1 tactic, akin to "pain compliance applied through the use of distraction, counter-joint holds, hair control holds, [and pepper spray]" and used to control passively or actively resisting suspects.

CEW drive-stun applications have no clinically significant physiological or pathological effects.

D. Current Flow in the Body

The flow of electrical current in the body is well understood and has been the subject of 100's of scientific papers.[124,209-217] The simplest analogy is the 1^{st} to 2^{nd} baseline in baseball. See Figure 17. The runners can go directly between the bases but they typically curve out a bit. Similarly, with 2 electrodes in the skin, the current flow "dives" in somewhat just like a runner's path in baseball. The further the electrodes are apart, the deeper the "dive" of the current. This analysis is accurate for a homogenous conductor like saltwater or fat. However, the body's skeletal muscle layer preferably directs current around the outside of the body since electrical current vastly prefers to follow the grain of the muscle instead of going transverse and penetrating the body.

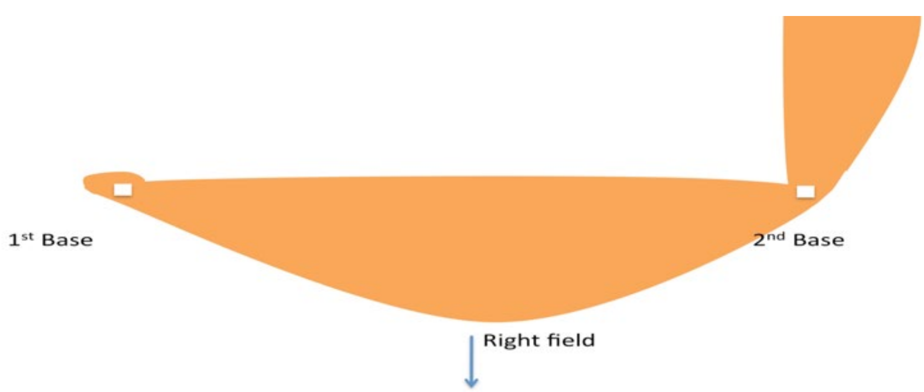

Figure 17. Graphic of electrical current flow in the body analogized to baseball.

Some medical examiners have wrongly opined that since they witnessed a subject experience board-like lockup induced by a CEW that the current flows everywhere even inside the body.

A runner might deviate somewhat from a straight line but would never run out into the outfield or wander into the bleachers. Similarly, with 2 CEW electrodes on the chest, no current passes into the legs or brain. That would be like a runner going into the outfield and then climbing up into the seats and then back to 2nd base.

An important exception occurs around bone. Mature calcified bone is an insulator and can thus not conduct electrical current.[218] A CEW probe landing in the sternum will pass very little current. What current is passed will be defused around the surface of the chest and will tend to not affect the heart even though parts of the heart are directly beneath the sternum.[209,219]

Electrical current in the body tends to follow muscle fiber and only deviates slightly.

E. CEW Comparison to Other Nerve Stimulators

TASER CEWs deliver less current than typical models of EMS (Electrical Muscle Stimulator) units. It is very popular in Europe to use TENS (Transcutaneous Electronic Nerve Stimulator) units for treating angina with the electrodes placed across the cardiac silhouette.[220-222] No deaths have been reported.

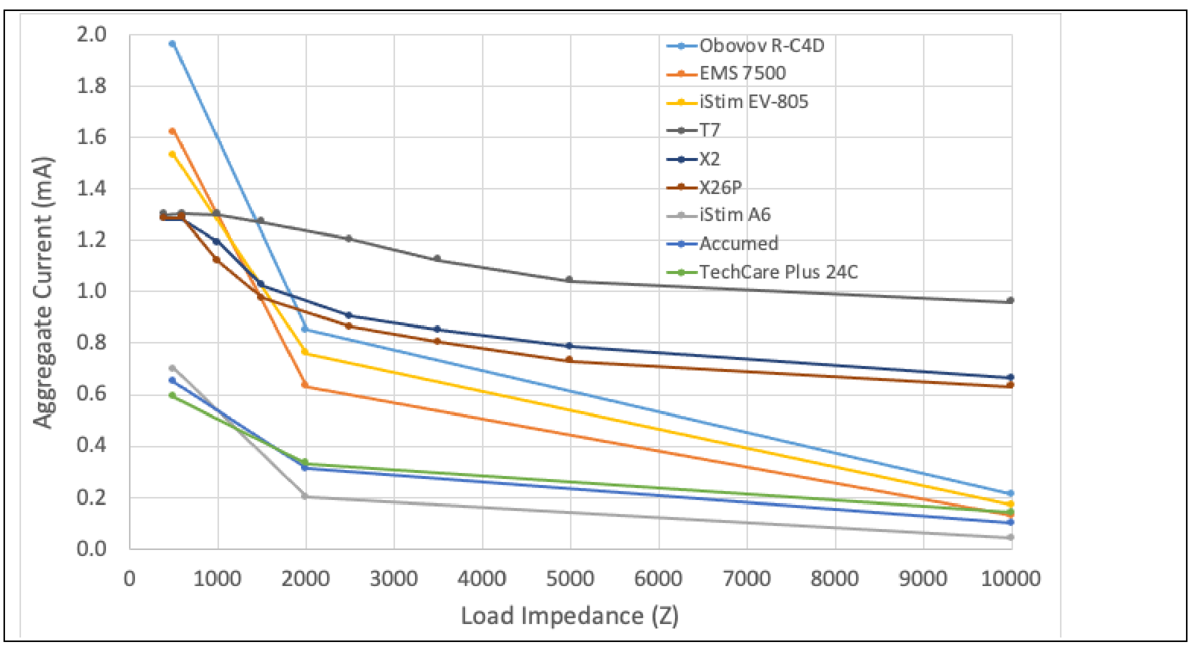

Figure 18. Aggregate current vs. load impedance.

The outputs of the TENS and EMS units are compared with the electrical-weapon muscle stimulators as seen in Figure 18. In the typical impedance

range of around 500 Ω, the EMS units delivered the most current followed by the CEWs (T7, X2, and X26P).[1]

F. ANSI CPLSO-17 Standard

All present TASER brand electrical weapon outputs exceed the minimum requirements for effectiveness under the ANSI CPLSO-17 standard. These output levels are also below the maximum safety limits under the ANSI CPLSO-17 standard of 2.2 mA.

G. CEW Comparison to the Electric Fence

It is helpful to discuss the most common and longest existing electronic control device — which controls humans and other mammals by giving short painful electrical stimuli — namely the electric fence.

The IEC (International Electrotechnical Commission)and UL (Underwriters Laboratories) have long had standards for electric fences.[48,49] These are the Particular Requirements for Electric Fence Energizers. IEC 60335-2-76, edn 2.1, and the UL Standard for Electric-Fence Controllers in: Laboratories U, ed. UL 69. Independent testing has verified that the TASER X26E CEW satisfies both the IEC and UL electric fence standards.[44] The X2 and the X26P CEWs also satisfy these standards.[45]

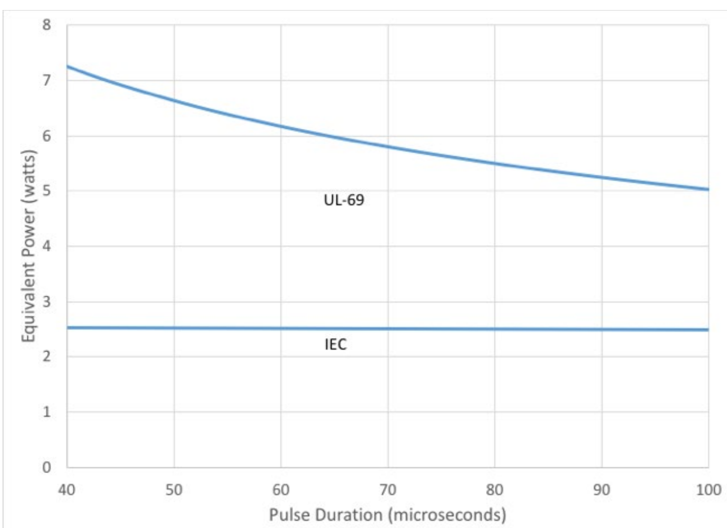

Figure 19. UL 69 electric fence equivalent power safety limit.

The X26 CEW satisfies the electric fence standards by a very wide margin.[44] The conservative IEC standard allows up to 2.5 watts (W) for an electric fence and all present TASER CEWs deliver <1.8 W. The UL high-rate limits are found in section in 23.2.4 of the UL standard 69.[49] This limit is shown in Figure 19 which allows 5 W for the wider-pulse X26 CEW and 6 W for the narrow-pulse X2 CEW. The electric fence standards have evolved from almost 100 years of experience

with documented fatalities from earlier high-powered devices. The UL carefully collected data on these units to find out what was a safe limit. The typical accidental exposure to an electric fence is based on someone walking into it and thus is a frontal exposure. Depending upon the relative heights of the fence and the individual this exposure could be anywhere from the face to the thighs and could include skin penetration from barbs on barbed wire. These limits are very stringent and now fatalities from electric fences are almost unheard of in spite of there being on the order of 100,000 miles of electric fence in the United States alone.

The TASER X26 CEW satisfies the International and UL electric fence standards by a wide margin and can be thus deemed very safe.

H. Comparison to General International Safety Standards

The IEC has set 40 mA AC as a safe level of utility (50/60 Hz) electrical current for avoiding the risk of VF induction (electrocution).[48,117] Rapid short-pulse stimulation has the same risk of VF induction as does utility power frequencies at a current of 9 times higher than the average current of the rapid pulses. The *TASER X26E CEW* delivers about 18 pulses per second at a charge of about 100 μC (microcoulombs) per pulse.[223] This gives an average current of 1.8 mA which corresponds to a utility power current of 16 mA. This is seen to be less than 1/2 of the IEC VF safety level.

The TASER X2 and X26P CEWs delivers about 19 pulses per second at a charge of about 63 μC (microcoulombs) per pulse.[223] This gives an average current of 1.18 mA which corresponds to a utility power current of 10.6 mA = 1.18 mA • 9.0. This is seen to be less than 1/4 of the IEC VF safety level. The TASER X26E, X2, and X26P CEWs satisfy all relevant international electrical safety standards.[45,47]

The available TASER CEWs satisfy all relevant electrical safety standards.

I. Electricity Does Not Build Up Like Poison: Baseball vs. Science

It is often alleged that multiple CEW applications are somehow more dangerous than a single standard 5-second CEW application. This can seem to be very intuitively appealing as multiple baton strikes and multiple bullet wounds are more dangerous than single ones. This intuition is, however, completely wrong and contrary to decades of scientific research. Due to the prevalence of this false intuition — even among some clinicians and pathologists — it is helpful to present a fairly lengthy discussion of the scientific facts below.

In fact, 1 second is the official implied value used by UL for their electrical safety standards. [130] The IEC uses a more gradual transition out to about 3 seconds as seen in Figure 20. Note that the UL has a slightly stricter safety limit for VF than does the IEC but that is not relevant to this discussion.

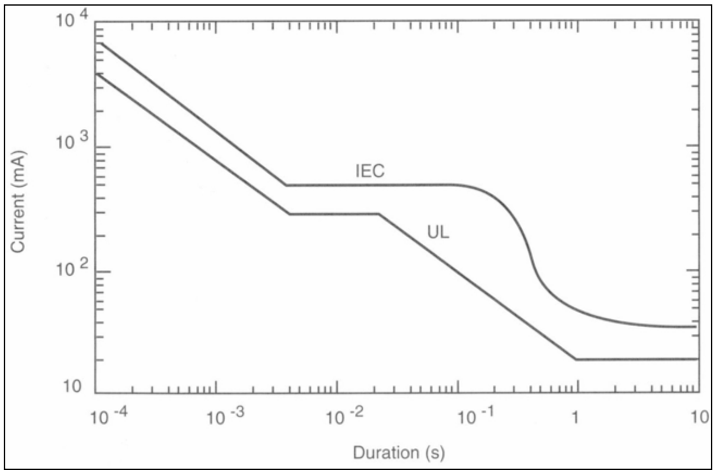

Figure 20. UL and IEC standards recognize that VF is induced or not within 1-5 seconds.

These standards are supported by numerous animal and human studies. The "electrocution time" is the number of seconds after which VF is either induced or not induced with a certain level of electrical current. A summary of studies of the transition time is given in Table 14.

Table 14. Maximum electrocution times from various studies

Author	Model	Transition Time (seconds)
Antoni[31]	guinea pig	0.8
Wegria[32]	exposed dog hearts	0.2
Ferris[33]	sheep	1.4
Jacobsen[34]	swine	4.0
Roy[35]	dog	2.0
Scott[36]	dog	< 3.0
Kiselev[37]	dog	< 5.0

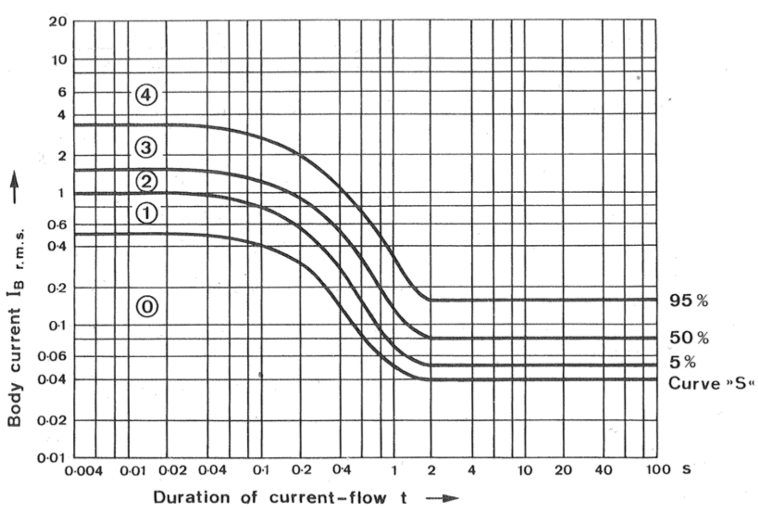

Figure 21. Original Biegelmeier curves showing safe (S) currents for humans.

Using calculations based on the human heart rate, Biegelmeir and Lee determined that the transition time for humans is 2-5 seconds.[117,118] See Figure 21. In a human study, Swerdlow et al showed that the VFT decreased by 47% with durations going from 1-5 seconds, consistent with the calculations of Biegelmeier.[129]

In a canine study, Scott et al found that the VFT did not change with durations going from 3 out to 60 seconds.[36] Kiselev also found the VFT to be quite constant from 5 to 30 seconds.[37] Scott states in his conclusions:

> Shocks of 3, 10, 30, and 60 seconds duration produced very similar mean [VFT] values. The stability of mean [VFT] over this wide range of shock duration suggests a basal threshold of fibrillation. Currents below this threshold seem unable to induce fibrillation regardless of shock duration.[36]

Scott's study showed that nothing happens between 3 and 60-second applications of current. Importantly he did this study in 16 canines, which have hearts that are electrically similar to humans — unlike pigs.[224-228]

The Dogma Of 3 Strikes And 15 Seconds

While anesthetized animals have been tested up to 30 minutes, human CEW testing has to be performed on volunteers. Law-enforcement trainees are often required to take a 5-second CEW exposure but it is very difficult to find volunteers willing to expose themselves to more than 10 or 15 seconds. Therefore, most clinical trials of the physiological effects of the TASER CEW, involve exposures of 5, 10, or 15 seconds. For example, there are a number of studies with continuous 15-second exposures.[229-232]

The independent review of Pasquier found:

> According to the available results, the physiologic changes from electronic control device exposure appear to be safe in healthy individuals who undergo an exposure duration of 5 to 15 seconds, i.e., the duration that corresponds to the majority of field exposures."[233]

Importantly, these clinical studies failed to find any trends for increased effects between 5, 10, and 15 seconds so there has been no evidence to motivate longer-duration studies. Dawes observed, "… the duration of the exposure does not appear to have a significant effect on CK [creatine kinase]."[12]

There is certainly a false lay-intuition that electrical charge must build up like poison since baton strikes and bullet wounds do tend to injure in a cumulative fashion. However, over 100 years of electrical research has demonstrated that the direct effects of electricity do not build up like poison. Specifically, the US military has tested this in swine with continuous CEW exposures across the whole chest up to 30 minutes — not 30 seconds.[116] If someone is electrocuted this generally occurs within 1 second with an upper limit of about 2-5 seconds.[117,118] If an electrical current is strong enough to kill someone it will do so

in the first few seconds of exposure and a longer exposure duration simply has no additional effect. With a full-trunk human exposure, there is a slight pH shift (blood becomes less alkaline) in the first few seconds but then does not change.[13,16,143,146,234-238] For a given degree of subject resistance, the more the CEW is used, the better the outcome will tend to be since the use of more conventional force control options can be reduced. [39,239-243]

The epidemiological data unambiguously finds no increased risk with CEW exposures beyond 15 seconds:

1. Brewer studied 292 arrest-related-deaths (ARDs) where a CEW had been used.[91] He found that: (1) over 75% of the 292 deaths involved only 1 or 2 CEW exposures, (2) 85% of fatalities were preceded by 3 CEW exposures or less, and (3) concluded that there was no correlation between the number of CEW exposures and the mortality rate.

2. White studied 188 ARDs where a CEW had been used and similarly found that 87% of them had 3 trigger pulls or less which is the equivalent of 15 seconds of discharge or less.[244]

The widespread dogmatic urban myth that 15 seconds is safe while 16 seconds is dangerous is contradicted by all of the relevant scientific studies and statistics.

The direct electrical induction of VF by electrical currents takes 1-5 seconds.

J. The Handheld CEW Has Led to Dramatic Reductions in Injury.

Numerous published studies have now clearly demonstrated substantial injury and fatality reductions from the use of TASER CEWs compared to alternative control techniques.[39,245-251]

A partial list of these studies includes:

1. Bozeman comparison to other force options, including physical force.
2. MacDonald which compared the CEW to pepper spray and "physical force."[39]
3. Taylor which compared the CEW to pepper spray, baton strikes, and "hands-on."[40]
4. Mesloh who studied CEW usage in comparison to many control options.[240,247]
    a. Gentle hold
    b. Handcuff
    c. Leg restraints
    d. Pepper spray
    e. Compliance holds
    f. Takedown
    g. Empty hand strike

h. FN303/Pepperball
i. Impact weapon
j. Canine

The largest epidemiological study was the 2009 MacDonald study of 24,380 uses of force.[39] This study found that CEW usage dramatically reduced both subject and officer injury (by 2/3) compared to alternative force options. Additional studies demonstrating injury reduction are memorialized in the papers of Taylor (13,983 subjects)[40], Mesloh (n = 4303)[247], Smith (n = 1645)[241], Butler (n = 562)[242], White (n = 243)[183], and Bozeman (n = 893).[251]

On average, the use of the CEW reduces subject injuries by about 2/3. To put it another way, the use of alternative control techniques triples (3x) the risk of injury to subjects. Fatal suspect shootings are also reduced by 2/3 when electronic control is used without excessive restriction. [42]

a. The deployment and use of TASER CEWs has been shown to reduce injuries to officers and subjects over other force options, including physical force.[39]
b. The deployment and use of TASER CEWs has been shown to reduce use-of-force civilian complaints and law enforcement internal affairs complaints against law enforcement officers.[252]
c. The deployment and use of TASER CEWs has resulted in the reduced need to use deadly force.[42,90]
d. Rates of injury from TASER CEWs is less than several other common law enforcement force options, including, but not limited to: physical force, chemical aerosols, batons, impact tools, canines, rubber bullets, and bean bags.
e. TASER CEWs are a safer alternative than other comparable law enforcement force options tools or techniques.
f. TASER CEWs are shown to reduce subject injuries when compared to physical force options.
g. TASER CEWs have greater accountability features than any other force option.
h. TASER CEWs are the most studied force option available to law enforcement.
i. TASER CEWs are the most effective force option in gaining compliance without need for deployment or application (up to 81%).[253]

The TASER CEW reduces subject injuries and fatalities.

General Comments

Previous Testimony

I have testified as an expert at trial or by deposition within the preceding 4 years in:

1. Patent Inter-Party Review of Nevro v Boston Scientific re US #6895280, Wash. DC. US Patent Appeals Board. (Apr 2018) P
2. Patent Inter-Party Review of Nevro v Boston Scientific re US #7587241, Wash. DC. US Patent Appeals Board. (Apr 2018) P
3. Wrongful death case of Aguilar v Los Angeles PD. US District Court, Los Angeles, CA. (May 2018 and May 2019) D
4. Wrongful death case of Ramos v East Hartford, CT. US District Court, Hartford, CT. (June 2018) D
5. Wrongful death case of Todero v Greenwood, IN. US District Court, Indianapolis, IN (Sept 2018) D
6. Wrongful death case of Silva (Haleck) v Honolulu, HI. US District Court, Honolulu. (May 2019) D
7. Wrongful death case of Wood v Entergy. Arkansas District Court, AR. (May 2019) P
8. Patent case of Cardionet v Infobionics. US District Court, Boston, Massachusetts. (Sept 2019) D
9. Labor arbitration of Payne v Omaha, NE. US Dept of Labor (Oct 2019) P
10. Wrongful death case of Timpa v Dallas, TX. US District Court, Dallas, TX (Dec 2019) D
11. Criminal case of USA vs. Burton Ritchie. US District Court, Las Vegas, NV (Jan 2020) P
12. Starke v Astar et al. Florida District Court, St. John's County, FL (Apr 2020) D
13. Patent Inter-Party Review of Nevro v Boston Scientific re US #9162071, Wash. DC. US Patent Appeals Board. (Apr 2020) P
14. Patent Inter-Party Review of Nevro v Boston Scientific re US #8682447, Wash. DC. US Patent Appeals Board. (Apr 2020) P
15. Patent Inter-Party Review of Nevro v Boston Scientific re US #6381496, Wash. DC. US Patent Appeals Board. (Apr 2020) P
16. Loftis v American Electric Power. US District Court, Charleston, WV (Oct 2020) D
17. Valear v Q3. Colorado Dst Ct., Denver Cty, CO. (June and Oct 2021) D
18. Georgia v Howell, Scott, and Copeland. Georgia District Court, GA. (Oct 2021) D
19. Harris v Rambosk. US District Court, FL (Oct 2021) D
20. Dold v. Snohomish County. US District Court, WA (Jan 2022) D
21. Adkins v. Appalachian Power. US District Court, WV (Jan 2022) D

Fees:

My fees for this expert consultant report are $480 per hour for the research and preparation, plus expense reimbursement. My fees for testimony (at trial or deposition) are $480 per hour plus anticipated expense reimbursement and are due prior to the commencement of a deposition. Fees for travel are portal-to-portal and are $240 per hour when not performing work billable at $480 per hour.

Right To Amend:

The opinions in this report are living opinions. Should additional discovery material be received, or additional research be completed, and then reviewed, these opinions may be altered or reinforced depending upon what information is obtained, reviewed, or studied. If new issues are opined, identified, or developed subsequent to submission of this report, I reserve the right to supplement, or further supplement, this report. *I especially reserve the right to amend my report after receiving new forensic evidence.*

Further Development:

Further, the opinions, which are expressed in this report, are listed to comply with current report requests. Each opinion may be further developed through research, investigation, during deposition or trial testimony.

Specific References:

Some of the opinions in this report may list specific references to some of the case specific documents reviewed or considered. These listings are not intended to be all-inclusive. I specifically reserve the right to supplement the support for each of the opinions in this report.

Opinion Methodology:

The enclosed opinions were developed using the disciplines of bioelectricity, electrophysiology, biomedical science, cardiovascular physiology, scientific methods, mathematics, and physics and are to a reasonable degree of professional and scientific certainty.

Additionally, the opinions provided in this case were developed using one or more qualitative and quantitative research methodologies, in addition to my education, training, experience, and literature review.

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Expert Consulting Fee Schedule

Date: 14 Jan 2021
From: Mark W. Kroll, PhD, FACC, FHRS, FIEEE, FAIMBE
Email: mark@kroll.name
Mobile: +1-805-428-1838

1. ***Retention, consulting, testimony, travel, on-site-visit, and other fees:***
   a. **Non-Refundable Retention:** The minimum *non-refundable* charge for the incident, litigation, or other consulting services or retention is $4800, which will be invoiced and immediately due upon initial retention. For consideration of the retainer, Mark Kroll & Associates agrees to reserve sufficient mutually-agreed upon time to perform consulting services and deliver any expert report within the mutually agreed upon specified deadline and to allow the client to use Kroll's name in settlement negotiations. The hourly rate to be charged against this minimum retention is $480 per hour.
   b. **Sworn Testimony:** The rate for sworn testimony is $700 per hour discounted to $600 per hour for online testimony or testimony in Minnesota. The minimum charge for sworn testimony is $4200 and must be received 14 days before. Deposition preparation charges are billed at 20% of the total charges incurred for the written report.
   c. **Travel Time Charge:** For travel to a testimony location, or any other travel time such as an onsite visit, client meeting, or overnight stay, the charge is $240 per hour plus ordinary travel expenses. Will fly upgradeable Economy class within the USA.
   d. **Minimum Traveling Day Charge:** For a full 24 hours away from Minneapolis, the minimum daily rate is $8520 and calculated as follows:
      - 6 hours preparation or testimony @ $700 = 4200
      - 18 hours travel time @ $240 = 4320

      If a given day involves more than 6 hours of work, then the charges for that day will exceed $8520.
   e. **Deposition by Remote Means:** Video depositions are acceptable using high-quality equipment meeting the H.264 standard. High-bandwidth Zoom-type depositions are acceptable so long as all attorneys and reporter are visible. ***Pure audio (telephone) depositions are not acceptable.***
   f. **Late Payments:** Invoices not paid within 30 days will incur 1% per month interest.
2. ***Pro bono work:***
   a. I will do expert consulting on a *pro bono* basis for cases where there is legitimate need and an officer is facing criminal charges.
   b. This is limited to a single (1) case per year.
3. ***Retaining counsel agrees:***
   a. If any entity other than the client is responsible for payment of deposition or any other fees or expenses, then retaining counsel agrees to collect same at least 14 days before the scheduled deposition or provide the fee and expenses directly to me.
   b. To notify and electronically provide all related documents, within 24 hours of filing, of any *Daubert*, *Frye*, Rule 703, *motion in limine,* or other such limiting motion, action, procedure, court order or ruling. If retaining counsel fails to do so — or fails to adequately vigorously defend me — I reserve the right to withdraw from the case, including prior to any action, ruling, or other determination by the court.
   c. To not stipulate to a low-quality video or any telephonic deposition under FRCP 30(b)(4).
4. ***I agree to:***
   a. Provide (for Federal Court cases) a quality report satisfying FRCP 26.
   b. Provide a draft report 7 days in advance of the deadline — assuming the evidence is furnished to me 2 months before the FRCP 26 deadline.

Form **W-9**
(Rev. December 2011)
Department of the Treasury
Internal Revenue Service

Request for Taxpayer Identification Number and Certification

Give Form to the requester. Do not send to the IRS.

Print or type
See **Specific Instructions** on page 2.

Name (as shown on your income tax return)
Mark W. Kroll

Business name/disregarded entity name, if different from above
Mark Kroll Associates

Check appropriate box for federal tax classification:
☑ Individual/sole proprietor ☐ C Corporation ☐ S Corporation ☐ Partnership ☐ Trust/estate

☐ Limited liability company. Enter the tax classification (C=C corporation, S=S corporation, P=partnership) ▶

☐ Other (see instructions) ▶

☐ Exempt payee

Address (number, street, and apt. or suite no.)
Box 23

City, state, and ZIP code
Crystal Bay, MN 55323

Requester's name and address (optional)

List account number(s) here (optional)

Part I Taxpayer Identification Number (TIN)

Enter your TIN in the appropriate box. The TIN provided must match the name given on the "Name" line to avoid backup withholding. For individuals, this is your social security number (SSN). However, for a resident alien, sole proprietor, or disregarded entity, see the Part I instructions on page 3. For other entities, it is your employer identification number (EIN). If you do not have a number, see *How to get a TIN* on page 3.

Note. If the account is in more than one name, see the chart on page 4 for guidelines on whose number to enter.

Social security number

– –

Employer identification number

20 – 4112949

Part II Certification

Under penalties of perjury, I certify that:

1. The number shown on this form is my correct taxpayer identification number (or I am waiting for a number to be issued to me), and
2. I am not subject to backup withholding because: (a) I am exempt from backup withholding, or (b) I have not been notified by the Internal Revenue Service (IRS) that I am subject to backup withholding as a result of a failure to report all interest or dividends, or (c) the IRS has notified me that I am no longer subject to backup withholding, and
3. I am a U.S. citizen or other U.S. person (defined below).

Certification instructions. You must cross out item 2 above if you have been notified by the IRS that you are currently subject to backup withholding because you have failed to report all interest and dividends on your tax return. For real estate transactions, item 2 does not apply. For mortgage interest paid, acquisition or abandonment of secured property, cancellation of debt, contributions to an individual retirement arrangement (IRA), and generally, payments other than interest and dividends, you are not required to sign the certification, but you must provide your correct TIN. See the instructions on page 4.

Sign Here **Signature of U.S. person ▶** **Date ▶** 14 January 2021

General Instructions

Section references are to the Internal Revenue Code unless otherwise noted.

Purpose of Form

A person who is required to file an information return with the IRS must obtain your correct taxpayer identification number (TIN) to report, for example, income paid to you, real estate transactions, mortgage interest you paid, acquisition or abandonment of secured property, cancellation of debt, or contributions you made to an IRA.

Use Form W-9 only if you are a U.S. person (including a resident alien), to provide your correct TIN to the person requesting it (the requester) and, when applicable, to:

1. Certify that the TIN you are giving is correct (or you are waiting for a number to be issued),

2. Certify that you are not subject to backup withholding, or

3. Claim exemption from backup withholding if you are a U.S. exempt payee. If applicable, you are also certifying that as a U.S. person, your allocable share of any partnership income from a U.S. trade or business is not subject to the withholding tax on foreign partners' share of effectively connected income.

Note. If a requester gives you a form other than Form W-9 to request your TIN, you must use the requester's form if it is substantially similar to this Form W-9.

Definition of a U.S. person. For federal tax purposes, you are considered a U.S. person if you are:

- An individual who is a U.S. citizen or U.S. resident alien,
- A partnership, corporation, company, or association created or organized in the United States or under the laws of the United States,
- An estate (other than a foreign estate), or
- A domestic trust (as defined in Regulations section 301.7701-7).

Special rules for partnerships. Partnerships that conduct a trade or business in the United States are generally required to pay a withholding tax on any foreign partners' share of income from such business. Further, in certain cases where a Form W-9 has not been received, a partnership is required to presume that a partner is a foreign person, and pay the withholding tax. Therefore, if you are a U.S. person that is a partner in a partnership conducting a trade or business in the United States, provide Form W-9 to the partnership to establish your U.S. status and avoid withholding on your share of partnership income.

CURRICULUM VITAE

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BASIC INFORMATION:

NAME:	Mark W. Kroll, PhD, FACC, FHRS, FIEEE, FAIMBE
OFFICE:	Box 23
	Crystal Bay, MN 55323 USA
PHONE:	+1-805-428-1838
E-MAIL:	mark@kroll.name
CITIZENSHIP:	United States
MARITAL STATUS:	Married, 4 children
LANGUAGES:	Spanish (Good)
	German (Usable)
	French (Reading Only)
H-INDEX:	79 (Google Scholar)

ACADEMICS:

ACADEMIC DEGREES:

1975	B. Mathematics
1983	M.S. Electrical Engineering
1987	Ph.D. Electrical Engineering
1990	M.B.A.

MEDICAL AND BIOMEDICAL RECOGNITIONS:

1996: American College of Cardiology: Fellow

2009: Heart Rhythm Society: Fellow

2009: Engineering in Medicine and Biology Society: Fellow

2013: American Institute for Medical and Biological Engineering: Fellow

EDUCATION:

1967-1970	Minnetonka High School Minnetonka, Minnesota
1969	Michigan State University (National Science Foundation High School Honors Summer Program) East Lansing, Michigan
1970-1975	University of Minnesota Minneapolis, Minnesota
1975-1979	University of Minnesota Graduate School Minneapolis, Minnesota
1988-1990	University of St. Thomas Minneapolis, Minnesota

ACADEMIC AFFILIATIONS:

2006-Present	Adjunct Full Professor, Biomedical Engineering University of Minnesota, Minneapolis
2003-Present	Adjunct Full Professor, Biomedical Engineering California Polytechnic State University, San Luis Obispo. (There was a 2-year hiatus from 2010 to Feb 2012)
2002-2016	Faculty for Creativity and Innovation Program UCLA

PROFESSIONAL POSITIONS:

Research Aide (1970-1972)

Medtronic, Inc., Minneapolis, Minnesota

Teaching Assistant and Graduate Instructor (1973-1978)

Economics, Mathematics & Electrical Engineering Departments

University of Minnesota, Minneapolis, Minnesota

Vice President, Research & Development (1978-1985)

Intercomp Company, Plymouth, Minnesota

Vice President, Research & Development (1985-1991)

Cherne Medical, Inc., Edina, Minnesota

Vice President, Research (1991-1995)

Angeion Corp., Plymouth, Minnesota

Vice President, Tachycardia Business Unit (1995-1997)

St. Jude Medical, Inc., Los Angeles, California

Vice President, Research and Development for Daig subsidiary (1997-1999)

St. Jude Medical, Inc. Cardiac Rhythm Management Division

Senior Vice President, Technology and Design (1999-2000)

St. Jude Medical, Inc. Cardiac Rhythm Management Division

Senior Vice President, Chief Technology Officer (2001-August 2005) St. Jude Medical, Inc. Cardiac Rhythm Management Division

Principal, Mark Kroll & Associates, LLC (March 2006 to present)

HONORS AND AWARDS:

1969	National Science Foundation High School Honors Program
1970	Putnam Varsity Team (Intercollegiate Mathematics Competition) when Freshman
1971	Alfred P. Sloan Fellowship
1971	Ellerbe Scholastic Award for Institute of Technology
1992	Who's Who in Science and Engineering
1993	Who's Who in the Midwest
1996	Who's Who in the West
1998	Prolific Inventor, U.S. Patent and Trademark Office
1997	Who's Who in Medicine and Healthcare
2010	Career Achievement Award by Engineering in Medicine and Biology Society
2012	Outstanding Achievement Award: Distinguished Graduate, University of Minnesota.
2016	Mark Kroll Medical Innovation Day proclamation by Minnesota Governor.

FOR-PROFIT BOARDS:

Haemonetics (NYSE:HAE)

Axon Enterprises (NASD:AAXN)

Prostacare (private)

VivaQuant (private)

NON-PROFIT BOARDS & MAJOR COMMITTEES:

IEC (International Electrotechnical Commission) TC64 MT4 committee (responsible for the basic international electrical safety standard 60479 series).

ANSI (American National Standards Institute) CPLSO committee for high-voltage security systems.

IEC TC85 committee (responsible for electrical measurement standards).

Lake Minnetonka Conservation District board

EDITORIAL ROLES:

Europace: Regular Reviewer
EMBS Conference: Regular Reviewer
Heart Rhythm Journal: Ad Hoc Reviewer
J of Cardiovascular Electrophysiology: Ad Hoc Reviewer
IEEE Trans on Biomedical Engineering: Ad Hoc Reviewer
Journal American College of Cardiology: Ad Hoc Reviewer
Pacing and Clinical Electrophysiology: Regular Reviewer
J Occupational & Environmental Medicine: Ad Hoc Reviewer
Journal of Medical Science: Ad Hoc Reviewer
IEEE Trans Biomedical Circuits & Systems: Ad Hoc Reviewer
J of Interventional Cardiac Electrophysiology: Regular Reviewer
J of Forensic & Legal Medicine: "Outstanding" Reviewer
Nature Scientific Reports: Ad Hoc Reviewer
J American Medical Association: Ad Hoc Reviewer
British Medical J: Ad Hoc Reviewer
Science & Justice: Ad Hoc Reviewer

ISSUED U.S. PATENTS:

4,672,976	Heart Sound Sensor
4,672,977	Lung Sound Cancellation Method and Apparatus
4,714,121	Wheel Scale Assembly
4,744,369	Medical Current Limiting Circuit
4,763,660	Flexible and Disposable Electrode Belt Device
4,769,760	Terrain Biased Dynamic Multiple Threshold Synchronization Method and Apparatus
4,775,018	Load Cell Assembly
4,811,156	Medical Current Limiter
4,832,608	Electrode Belt Adapter
4,879,760	Optical Fiber Transmissive Signal Modulation System
4,890,630	Bio-Electric Noise Cancellation System
4,947,859	Bio-Acoustic Sound Sensor
4,956,877	Optical Fiber Reflective Signal Modulation System
5,117,834	Method and Apparatus for Non-invasively Determining a Patient's Susceptibility to Ventricular Arrhythmias
5,188,116	Electrocardiographic Method and Device
5,199,429	Implantable Defibrillator System with Switched Capacitors
5,241,960	Small Implantable Cardioverter Defibrillator System
5,257,634	Low Impedance Defibrillation Catheter

5,258,906	Medical Metering and Invoicing Method
5,265,623	Optimized Field Defibrillation Catheter
5,300,110	Dirk Based Defibrillation Electrode
5,306,291	Optimal Energy Steering
5,312,443	Arrhythmia Detection Criteria Process
5,314,448	Pulse Pre-Treatment Method of Defibrillation
5,325,870	Multiplexed Defibrillation Electrode Apparatus System
5,330,509	Far-Field Anti-Tachycardia Termination
5,334,219	Separated Capacitor Cardioversion
5,336,245	Electrogram Interrogation Apparatus Storage
5,342,399	Process for Defibrillation with Small Capacitor
5,351,687	Method and Apparatus for Non-invasively Determining a Patient's Susceptibility to Ventricular Arrhythmias
5,366,484	Narrow Pulse Cardioversion
5,366,485	Pulse Pretreatment Device
5,366,487	Pulse Correlation Detection Method
5,376,103	Improved Electrode System
5,383,907	System and Method for Delivering Multiple Closely Spaced Defibrillation Pulses
5,391,185	Atrial Cardioverter with Ventricular Protection

5,391,186	Method and Apparatus for Utilizing Short TAU Capacitors in an Implantable Cardioverter Defibrillator
5,405,363	Implantable Cardioverter Defibrillator Having a Smaller Displacement Volume
5,407,444	Cardioversion Method
5,411,526	True Voltage Pulse Defibrillation
5,413,591	Current Truncated Waveform Defibrillator
5,431,686	Optimal Pulse Duration
5,431,687	Impedance Timed Defibrillation System
5,439,482	Prophylactic Implantable Cardioverter Defibrillator
5,441,518	Implantable Cardioverter Defibrillator System Having Independently Controllable Electrode Discharge Pathway
5,447,521	Safety System for an Implantable Defibrillator
5,449,377	Overcharged Final Countershock for an Implantable Cardioverter Defibrillator and Method
5,454,839	Low Profile Defibrillation Catheter
5,458,620	Interdependent Detection Parameter Method of Diagnosing Fibrillation
5,507,781	Implantable Defibrillator System with Capacitor Switching Circuitry
5,514,160	Implantable Defibrillator for Producing a Rectangular-Shaped Defibrillation Waveform
5,522,853	Method and Apparatus for Progressive Recruitment of Cardiac Fibrillation

5,527,346	Implantable Cardioverter Defibrillator Employing Polymer Thin Film Capacitors
5,531,764	Implantable Defibrillator System and Method Having Successive Changeable Defibrillation Waveforms
5,531,766	Implantable Cardioverter Defibrillator Pulse Generator Kite-Tail Electrode System
5,531,770	Implantable Defibrillator for Producing a Rectangular – Shaped Defibrillation Waveform
5,531,782	Implantable Medical Electrode with Reduced Number of Conductors
5,534,015	Method and Apparatus for Generating Biphasic Waveforms in an Implantable Defibrillator
5,540,721	Process and Apparatus for Defibrillation with a Small Capacitor
5,549,643	Optimal Pulse Defibrillator
5,549,933	Process for Painting Snow; Powder; Nontoxic
5,584,866	Method and Apparatus for Temporarily Electrically Forcing Tachyarrhythmia Patient
5,591,209	Implantable Defibrillator System for Generating an Active Biphasic Waveform
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5,662,696	One Piece Disposable Threshold Test Can Electrode for Use with an Implantable Cardioverter Defibrillator System
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5,735,876	Electrical Cardiac Output Forcing Method and Apparatus for an Atrial Defibrillator
5,735,878	Implantable Defibrillator Having Multiple Pathways
5,738,105	Method and Apparatus for Sensing R-Waves Using Both Near Field and Far Field Sensing Simultaneously
5,741,303	Electrode Back-Charging Pre-Treatment System for an Implantable Cardioverter Defibrillator
5,741,307	Method for Determining an ICD Replacement Time
5,749,910	Shield for Implantable Cardioverter Defibrillator
5,761,019	Medical Current Limiter
5,772,689	Implantable Cardioverter-Defibrillator with Apical Shock Delivery
5,772,690	System Having a Surrogate Defibrillation Electrode for Testing Implantable Cardioverter-Defibrillators During Implant
5,782,883	Suboptimal Output Device to Manage Cardiac Tachyarrhythmias
5,814,075	Method and Apparatus for Optimizing Source Allocation Within an Implantable Cardioverter-Defibrillator
5,827,326	Implantable Cardioverter Defibrillator Having a Smaller Energy Storage Capacity
5,830,236	System for Delivering Low Pain Therapeutic Electrical Waveforms to the Heart
5,833,712	Implantable Defibrillator System for Generating a Biphasic Waveform

5,836,973	Staged Energy Concentration for an Implantable Biomedical Device
5,861,006	System for Selectively Reforming an ICD
5,871,505	Apparatus for Generating Biphasic Waveforms in an Implantable Defibrillator
5,871,510	Method and Apparatus for Temporarily Electrically Forcing Cardiac Output as a Backup for Tachycardia Patients
5,899,923	Automatic Capacitor Maintenance System for an Implantable Cardioverter Defibrillator
5,904,705	Automatic Battery-Maintaining Implantable Cardioverter Defibrillator and Method for Use
5,906,633	System for Delivering Low Pain Therapeutic Electrical Waveforms to the Heart
5,913,877	Implantable Defibrillator System for Generating a Biphasic Waveform with Enhanced Phase Transition
5,925,068	Method for Determining an ICD Replacement Time
5,925,066	Atrial Arrhythmia Sensor with Drug and Electrical Therapy Control Apparatus
5,944,746	ICD with Continuous Regular Testing of Defibrillation Lead Status
5,957,956	Implantable Cardioverter Defibrillator Having a Smaller Mass
5,978,703	Method and Apparatus for Temporarily Electrically Forcing Cardiac Output in a Tachyarrhythmia Patient
5,988,161	Altitude Adjustment Method and Apparatus
6,007,395	Sun Tanning Life Vest

6,041,255	Disposable External Defibrillator
6,062,474	ATM Signature Security System
6,093,982	High Voltage Output Array Switching System
6,101,414	Method and Apparatus for Antitachycardia Pacing with an Optimal Coupling Interval
6,112,118	Implantable Cardioverter Defibrillator with Slew Rate Limiting
6,115,597	Disposal Emergency Cellular Phone
6,132,426	Temperature and Current Limited Ablation Catheter
6,167,306	Method and Apparatus for Electrically Forcing Cardiac Output in an Arrhythmia Patient
6,169,923	Implantable Cardioverter-Defibrillator with Automatic Arrhythmia Detection Criteria Adjustment
6,185,457	Method and Apparatus for Electrically Forcing Cardiac Output in an Arrhythmia Patient
6,198,249	Thermal Booster Battery System
6,208,899	Implantable Cardioversion Device with Automatic Filter Control
6,219,582	Temporary Atrial Cardioversion Catheter
6,233,483	System and Method for Generating a High Efficiency Biphasic Defibrillation Waveform for Use in an Implantable Cardioverter/ Defibrillator (ICD).
6,282,444	Implantable Device with Electrical Infection Control
6,287,306	Even Temperature Linear Lesion Ablation Catheter
6,292,694	Implantable Medical Device Having Atrial Tachyarrhythmia Prevention Therapy

6,314,319	Method and Apparatus for Temporarily Electrically Forcing Cardiac Output in a Tachyarrhythmia Patient
6,327,498	Implantable Stimulation Lead for Use with an ICD Device Having Automatic Capture Pacing Features
6,345,200	Implant Guiding Programmer for Implantable Cardioverter Defibrillator
6,350,168	Light Selective Sport Garments
6,366,808	Implantable Device and Method for the Electrical Treatment of Cancer
6,370,234	Public Service Answering Point with Automatic Triage Capability
6,405,922	Keyboard Signature Security System
6,408,206	Disposable External Defibrillator
6,411,844	Fast Recovery Sensor Amplifier Circuit for Implantable Medical Device
6,438,426	Temporary Atrial Cardioversion Catheter
6,442,426	Implantable Ventricular Cardioverter-Defibrillator Employing Atrial Pacing for Preventing Atrial Fibrillation from Ventricular Cardioversion and Defibrillation Shocks
6,445,949	Implantable Cardioversion Device with a Self-Adjusting Threshold for Therapy Selection
6,445,950	Implantable Cardioverter/Defibrillator Employing Shock Delivery Timing for Preventing Induced Fibrillation
6,456,876	Dual-Chamber Implantable Cardiac Stimulation System and Device with Selectable Arrhythmia Termination Electrode Configurations and Method

6,484,056	System and Method of Generating a High Efficiency Biphasic Defibrillation Waveform for Use in an Implantable Cardioverter/ Defibrillator (ICD)
6,539,254	Implantable Ventricular Cardioverter-Defibrillator Employing Atrial Pacing for Preventing Atrial Fibrillation from Ventricular Cardioversion and Defibrillation Shocks
6,549,806	Implantable Dual Site Cardiac Stimulation Device Having Independent Automatic Capture Capability
6,549,807	Implantable Cardioverter Defibrillator Having a Rechargeable, Fast-Charging Battery and Method Thereof
6,560,484	Method and Apparatus for Electrically Forcing Cardiac Output in an Arrhythmia Patient
6,560,974	Nitrogen-Based Refrigerator Crisper
6,561,185	Altitude Adjustment Method and Apparatus
6,567,697	External Defibrillator with Electrical CPR Assist
6,578,499	Wind and Insect Resistant Picnic System
6,580,908	Generic Number Cellular Telephone
6,580,915	Aircraft Internal EMI Detection and Location
6,590,534	Electronic Car Locator
6,609,027	His Bundle Sensing Device and Associated Method
6,625,493	Orientation of Patient's Position Sensor Using External Field
6,628,986	System for Predicting Defibrillation Threshold Based on Patient Data

6,645,153	System and Method for Evaluating Risk of Mortality Due to Congestive Heart Failure Using Physiologic Sensors
6,658,292	Detection of Patient's Position and Activity Using 3D Accelerometer-Based Position Sensor
6,662,047	Pacing Mode to Reduce Effects of Orthostatic Hypotension and Syncope
6,687,542	XY Selectable Lead Assembly
6,694,188	Dynamic Control of Overdrive Pacing Based on Degree of Randomness Within Heart Rate
6,714,818	System and Method of Generating an Optimal Three-Step Defibrillation Waveform for Use in an Implantable Cardioverter/Defibrillator (ICD)
6,731,982	Anti-Tachycardia Pacing Methods and Devices
6,738,663	Implantable Device and Method for the Electrical Treatment of Cancer
6,744,152	Implantable Cardioverter Defibrillator with Switchable Power Source and Patient Warning System Cardiac Device
6,745,073	System and Method of Generating a Low-Pain Multi-Step Defibrillation Waveform for Use in an Implantable Cardioverter/Defibrillator (ICD)
6,748,261	Implantable Cardiac Stimulation Device for and Method of Monitoring Progression or Regression of Heart Disease by Monitoring Interchamber Conduction Delays
6,751,503	Methods and Systems for Treating Patients with Congestive Heart Failure (CHF)
6,754,531	Anti-Tachycardia Pacing Methods and Devices

6,760,625	Battery Monitoring System for an Implantable Medical Device
6,763,266	System and Method of Generating a Low-Pain Multi-Step Defibrillation Waveform for Use in an Implantable Cardioverter/Defibrillator (ICD)
6,766,194	Dynamic Control of Overdrive Pacing Based on Degree of Randomness Within Heart Rate
6,766,196	Anti-Tachycardia Pacing Methods and Devices
6,772,007	System and Method of Generating a Low-Pain Multi-Step Defibrillation Waveform for Use in an Implantable Cardioverter/Defibrillator (ICD)
6,775,571	Dynamic Control of Overdrive Pacing Based on Degree of Randomness Within Heart Rate
6,780,181	Even Temperature Linear Lesion Ablation Catheter
6,795,731	Anti-Tachycardia Pacing Methods and Devices
6,804,577	Battery Monitoring System for an Implantable Medical Device
6,817,520	Magnetic Card Swipe Signature Security System
6,826,427	Methods and Devices for Inhibiting Battery Voltage Delays in an Implantable Cardiac Device
6,853,859	Electrical Cardiac Output Forcer
6,854,844	Tan-Thru Sunglasses
6,862,475	Pediatric Rate Varying Implantable Cardiac Device
6,865,420	Cardiac Stimulation Device for Optimizing Cardiac output with Myocardial Ischemia Protection
6,904,314	Automatic defibrillation threshold tracking

6,907,286	Anti-tachycardia pacing methods and devices
6,928,321	Hypnosis augmented ICD
6,931,278	Implantable cardioverter defibrillator having fast action operation
6,937,896	Sympathetic nerve stimulator and/or pacemaker
6,954,669	System and method of generating an optimal three-step defibrillation waveform for use in an implantable cardioverter/defibrillator (ICD)
6,961,615	System and method for evaluating risk of mortality due to congestive heart failure using physiologic sensors
6,964,116	Ambulatory hairdryer
6,968,574	Light selective sports garments
6,980,850	System and method for emulating a surface EKG using an implantable cardiac stimulation device
6,987,999	Implantable defibrillator with alternating counter electrode
6,993,379	System and method for emulating a surface EKG using an implantable cardiac stimulation device
6,997,180	Breathing gas therapeutic method and apparatus
7,003,348	Monitoring cardiac geometry for diagnostics and therapy
7,010,358	Single lead system for high voltage CHF device
7,010,346	Implantable medical device having atrial tachyarrhythmia prevention therapy

7,006,867	Methods and apparatus for overdrive pacing multiple atrial sites using an implantable cardiac stimulation device
7,006,347	Low deformation electrolytic capacitor
7,006,867	Methods and apparatus for overdrive pacing multiple atrial sites using an implantable cardiac stimulation device
7,010,346	Implantable medical device having atrial tachyarrhythmia prevention therapy
7,010,358	Single lead system for high voltage CHF device
7,016,720	System and method for monitoring blood glucose levels using an implantable medical device
7,020,521	Methods and apparatus for detecting and/or monitoring heart failure
7,024,243	System and methods for preventing, detecting, and terminating pacemaker mediated tachycardia in biventricular implantable cardiac stimulation device
7,029,443	System and method for monitoring blood glucose levels using an implantable medical device
7,043,301	Implantable cardiac stimulation system providing high output far-field pacing and method
7,062,328	System and method for providing improved specificity for automatic mode switching within an implantable medical device
7,072,712	Disposable external defibrillator with hinged housing halves
7,076,295	Automatic defibrillation shock energy adjuster

7,076,300	Implantable cardiac stimulation device and method that discriminates between and treats atrial tachycardia and atrial fibrillation
7,076,301	Implantable cardiac stimulation device that minimizes parasitic muscle stimulation and method
7,079,891	System and method for providing cardioversion therapy and overdrive pacing using an implantable cardiac stimulation device
7,103,412	Implantable cardiac stimulation device and method for detecting asymptomatic diabetes
7,113,822	System and method for providing cardioversion therapy and overdrive pacing using an implantable cardiac stimulation device
7,120,491	Implantable cardioversion device with a self-adjusting threshold for therapy selection
7,123,961	Stimulation of autonomic nerves
7,139,611	System and method for rejecting far-field signals using an implantable cardiac stimulation device
7,149,579	System and method for determining patient posture based on 3-D trajectory using an implantable medical device
7,149,584	System and method for determining patient posture based on 3-D trajectory using an implantable medical device
7,155,277	Pathway management for CHF patients
7,155,286	System and method for reducing pain associated with cardioversion shocks generated by implantable cardiac stimulation devices
7,158,825	Implantable cardioverter defibrillator with leakage detection and prevention system

7,158,826	System and method for generating pain inhibition pulses using an implantable cardiac stimulation device
7,162,299	ICD with VF prevention
7,164,944	Analgesic therapy for ICD patients
7,164,950	Implantable stimulation device with isolating system for minimizing magnetic induction
7,171,268	Implantable cardiac stimulation device providing accelerated defibrillation delivery and method
7,181,281	ICD using MEMS for optimal therapy
7,181,277	Methods and systems for reducing the likelihood of arrhythmia onset
7,181,269	Implantable device that diagnoses ischemia and myocardial infarction and method
7,177,684	Activity monitor and six-minute walk test for depression and CHF patients
7,175,271	Tan-thru glasses
7,177,684	Activity monitor and six-minute walk test for depression and CHF patients
7,181,269	Implantable device that diagnoses ischemia and myocardial infarction and method
7,181,277	Methods and systems for reducing the likelihood of arrhythmia onset
7,181,281	ICD using MEMS for optimal therapy
7,191,002	Anti-tachycardia pacing methods and devices

7,194,304	Implantable cardiac defibrillation assembly including a self-evaluation system and method
7,200,437	Tissue contact for satellite cardiac pacemaker
7,203,546	System and method of implementing a prophylactic pacer/defibrillator
7,203,547	System and method of implementing a prophylactic pacer/defibrillator
7,203,550	Implantable medical device with a current generated for infection control
7,212,855	System and method for providing preventive overdrive pacing and antitachycardia pacing using an implantable cardiac stimulation device
7,212,859	Dual-chamber implantable cardiac stimulation system and device with selectable arrhythmia termination electrode configurations and method
7,225,030	Management of implantable devices
7,225,029	Implantable cardiac therapy device with dual chamber can to isolate high-frequency circuitry
7,225,020	System and method for providing preventive overdrive pacing and antitachycardia pacing using an implantable cardiac stimulation device
7,225,029	Implantable cardiac therapy device with dual chamber can to isolate high-frequency circuitry
7,225,030	Management of implantable devices
7,231,255	System and method for reducing pain associated with cardioversion shocks generated by implantable cardiac stimulation devices

7,254,440	Implantable ischemia and myocardial infarction monitor and method
7,260,433	Subcutaneous cardiac stimulation device providing anti-tachycardia pacing therapy and method
7,270,411	Light selective sports garments
7,272,438	Mode switching heart stimulation apparatus and method
7,274,961	Implantable cardiac stimulation device and method that discriminates between and treats ventricular tachycardia and ventricular fibrillation
7,277,755	Subcutaneous cardiac stimulation device providing anti-tachycardia pacing therapy and method
7,283,871	Self adjusting optimal waveforms
7,292,886	Bifocal cardiac stimulation device and methods
7,295,873	Anti-tachycardia pacing method and apparatus for multi-chamber pacing
7,305,266	Cardiac stimulation devices and methods for measuring impedances associated with the heart
7,305,270	Cardiac pacing/sensing lead providing far-field signal rejection
7,308,305	Optimally timed early shock defibrillation
7,308,307	Implantable single-chamber atrial pacing device providing active ventricular far field sensing and rate limit
7,321,792	Pacing therapy and acupuncture
7,324,849	Methods and devices for inhibiting battery voltage delays in an implantable cardiac device

7,333,854	Orthostatic cardiac output response pacer for heart failure patients and diabetic patients
7,340,302	Treating sleep apnea in patients using phrenic nerve stimulation
7,359,752	Configurable test load for an implantable medical device
7,363,081	System and method for providing preventive over-drive pacing and antitachycardia pacing using an implantable cardiac stimulation device
7,363,086	Capture verification in respiratory diaphragm stimulation
7,369,898	System and method for responding to pulsed gradient magnetic fields using an implantable medical device
7,373,202	Unipolar and bipolar lead cardiac pacemaker and method for inhibiting anode stimulation
7,386,342	Subcutaneous cardiac stimulation device providing anti-tachycardia pacing therapy and method
7,386,343	Spectrum-driven arrhythmia treatment method
7,389,140	Adjustment of stimulation current path
7,398,122	Self adjusting optimal waveforms
7,403,823	Super plastic design for CHF pacemaker lead
7,412,285	Method and device for treating cancer with electrical therapy in conjunction with chemotherapeutic agents and radiation therapy
7,413,302	Tan thru glasses
7,414,534	Method and apparatus for monitoring ingestion of medications using an implantable medical device

7,421,292	System and method for controlling the recording of diagnostic medical data in an implantable medical device
7,438,283	Toddler stair safety system
7,444,154	Nuisance cell phone locator
7,447,544	System and method for controlling the recording of diagnostic medical data in an implantable medical device
7,450,995	Implantable cardiac stimulation device including an output circuit that provides arbitrarily shaped defibrillation waveforms
7,454,249	Early warning for lead insulation failure
7,457,636	Self defense cellular telephone
7,467,012	Respiration parameters controlled by heart rate
7,480,531	System and method for reducing pain associated with cardioversion shocks generated by implantable cardiac stimulation devices
7,483,715	Self defense cell phone with projectiles
7,520,081	Electric immobilization weapon
7,526,336	Left heart implantable cardiac stimulation system with clot prevention and method
7,540,605	Tan-through sunglasses
7,565,195	Failsafe satellite pacemaker system
7,570,995	Method for reforming a capacitor in an implantable medical device
7,577,478	Ischemia detection for anti-arrhythmia therapy

7,585,071	Tan thru glasses
7,587,239	Cardiac pacemaker system, lead and method for rejecting far-field signals
7,590,445	Indirect mechanical medical therapy system
7,596,410	Tiered antitachycardia pacing and pre-pulsing therapy
7,596,412	Opto-electrical coherence detection of hemodynamically compromising arrhythmia
7,610,090	Implantable medical device with automatic sensing adjustment
7,613,513	System and method for determining cardiac geometry
7,634,313	Failsafe satellite pacemaker system
7,640,065	Cardiac constraint/therapeutic stimulation device
7,653,440	Stimulation lead and methods of stimulating
7,654,230	Domestic animal telephone
7,654,964	System and method for detecting arterial blood pressure based on aortic electrical resistance using an implantable medical device
7,676,266	Monitoring ventricular synchrony
7,680,529	System and method for monitoring blood glucose levels using an implantable medical device
7,684,870	Direct current fibrillator
7,689,280	Automatic system for determining bi-ventricular pacing responders

7,706,864	Method and apparatus for electrically forcing cardiac output in an arrhythmia patient
7,711,415	Implantable devices, and methods for use therewith, for monitoring sympathetic and parasympathetic influences on the heart
7,720,549	Partially implantable system for the electrical treatment of abnormal tissue growth
7,756,577	Multi-modal medical therapy system
7,751,887	Tiered antitachycardia pacing and pre-pulsing therapy
7,747,320	Responding a partial lead failure in an implantable cardioverter defibrillator
7,742,811	Implantable device and method for the electrical treatment of cancer
7,738,954	His bundle control
7,747,320	Responding a partial lead failure in an implantable cardioverter defibrillator
7,751,887	Tiered antitachycardia pacing and pre-pulsing therapy
7,756,577	Multi-modal medical therapy system
7,787,961	Reduced-diameter body-implantable leads and methods of assembly
7,805,158	Self defense cell phone with acceleration sensor and emergency call button
7,809,439	Spectrum-driven arrhythmia treatment method
7,813,798	Systems and methods for preventing, detecting, and terminating pacemaker mediated tachycardia in

	biventricular implantable cardiac stimulation systems
7,848,804	Apparatus and related methods for capacitor reforming
7,848,806	Virtual electrode polarization for shock therapy
7,856,268	Ischemia detection for anti-arrhythmia therapy
7,859,818	Electronic control device with wireless projectiles
7,876,228	Method and apparatus for monitoring ingestion of medications using an implantable medical device
7,878,152	Domestic animal telephone
7,894,915	Implantable medical device
7,899,537	Pericardial cardioverter defibrillator
7,946,056	Ambulatory hairdryer
7,970,465	Decision paradigms for implantable cardioverter-defibrillators
7,986,965	Self defense cell phone with shocking circuitry
8,005,474	Cell phone locator method
8,014,854	Method and device for treating abnormal tissue growth with electrical therapy
8,060,200	Self-adjusting optimal waveforms
8,121,680	Subcutaneous cardiac stimulation device providing anti-tachycardia pacing therapy and method
8,099,174	Left heart implantable cardiac stimulation system with clot prevention electrode body coating and method
8,123,716	Pericardial delivery of treatment

8,160,655	Automatic recharging wireless headset
8,170,689	Implantable cardiac defibrillation system with defibrillation electrode entrapment prevention and method
8,200,330	Responding to partial lead failure in an implantable cardioverter defibrillator
8,201,522	Domestic animal telephone
8,269,635	Method and apparatus for monitoring ingestion of medications using an implantable medical device
8,269,636	Method and apparatus for monitoring ingestion of medications using an implantable medical device
8,340,731	Automatic recharging wireless headset
8,352,033	Apparatus and methods for measuring defibrillation lead impedance via a high magnitude, short duration current pulse
8,401,637	Medium voltage therapy applications in treating cardiac arrest
8,483,822	Adaptive medium voltage therapy for cardiac arrhythmias
8,551,019	Variable stiffness guide wire
8,577,425	Automatic recharging wireless headset
8,600,494	Method and device for treating abnormal tissue growth with electrical therapy
8,676,317	System and method for estimating defibrillation impedance based on low-voltage resistance measurements using an implantable medical device

8,700,156	High accuracy painless method for measuring defibrillation lead impedance
8,718,759	Multi-modal electrotherapy method and apparatus
8,750,990	Coordinated medium voltage therapy for improving effectiveness of defibrillation therapy
8,750,972	Implantable medical device with automatic sensing adjustment
8,805,495	Adaptive medium voltage therapy for cardiac arrhythmias
8,812,103	Method for detecting and treating insulation lead-to-housing failures
8,868,178	Arrhythmia electrotherapy device and method with provisions for mitigating patient discomfort
8,868,186	Methods for measuring impedances associated with the heart
9,061,164	Method for coordinating medium voltage therapy for improving effectiveness of defibrillation therapy
9,144,684	Medium voltage therapy applied as a test of a physiologic state
9,168,381	Arrhythmia electrotherapy device and method with provisions for inferring patient discomfort from evoked response
9,272,150	Method for detecting and localizing insulation failures of implantable device leads
9,333,009	Spinal correction system actuators
9,408,638	Spinal correction system actuators
9,421,391	Coordinated medium voltage therapy for improving effectiveness of defibrillation therapy

9,427,577	Method for detecting and treating insulation lead-to-housing failures
9,480,851	Multi-modal electrotherapy method and apparatus
9,636,500	Active surveillance of implanted medical leads for lead integrity
9,636,504	Arrhythmia electrotheraphy device and method with provisions for mitigating patient discomfort
9,675,799	Method and apparatus for implantable cardiac lead integrity analysis
9,713,727	Cardiac-safe electrotherapy method and apparatus
9,821,156	Apparatus for detecting and localizing insulation failures of implantable device leads
9,895,168	Spinal correction system actuators
9,987,485	Method and apparatus for implantable cardiac lead integrity analysis
10,039,919	Methods and apparatus for detecting and localizing partial conductor failures of implantable device leads
10,118,031	Method and apparatus for implantable cardiac lead integrity analysis
10,143,851	Arrhythmia electrotherapy device and method with provisions for mitigating patient discomfort
10,238,884	Cardiac-safe electrotherapy method and apparatus
10,252,069	Micro-charge ICD lead testing method and apparatus
10,675,062	Spinal correction system actuators

10,792,493	Method and apparatus for implantable cardiac lead integrity analysis
11,224,474	System for managing high impedance changes in a non-thermal ablation system for BPH

INTERNATIONAL PATENTS: (APPLICATIONS & GRANTS)

AU1305595A1	Method and Apparatus Utilizing Short Tau Capacitors
AU1305795A1	Implantable defibrillator employing polymer thin film capacitors
AU1696897A1	Medical current limiter
AU2003299471	Method and Device for Treating Cancer with Electrical Therapy in Conjunction with Chemotherapeutic Agents and Radiation Therapy
AU2012261983B2	Spinal correction system actuators
AU3625295A1	Low profile defibrillation catheter
AU697971B2	Medical current limiter
AU9048267	Bio-acoustic signal sensor
AU921460392A1	Electrocardiographic signal processing device
AU9513055	Implantable cardioverter defibrillator (extended shock duration)
AU9513057	Implantable cardioverter defibrillator (polymer thin film capacitors)
AU952637295	Implantable Defibrillator System for Generating Biphasic Waveforms
AU9539631	Implantable cardioverter defibrillator (stepped cardioversion)
AU9716968	Two terminal bi-directional medical current limiter
CA1291792	Flexible and Disposable Electrode Belt Device
CA2838047A1	Spinal correction system actuators
CN103781429B	Spinal correction system actuators
DE3637956	Flexible egwerfbare elektrodenbandvorrichtung (electrode belt)

DE60016125T	Implantable Cardioversion Device with Automatic Filter Control
DE60026121T	Implantable ventricular cardioverter/defibrillator employing atrial pacing for preventing atrial fibrillation from ventricular cardioversion and defibrillation shocks
DE60114507T	Method and apparatus for biventricular stimulation and capture monitoring
DE60203863T	XY Selectable lead assembly
DE60212280T	Pacing mode to reduce effects of orthostatic hypotension and syncope
DE60303758T	System for monitoring blood glucose levels using an implantable medical device
DE69218658	Implantable defibrillator system providing waveform optimization
DE69228735T2	Defibrillationssystem mit einem kleinen kondensator
DE69230430C0	Vorrichtung zur behandlung von herz vor einer defibrillation
DE69319641T2	Detektion von tachykardie und herzflimmern
DE69320474T2	Implantierbarer kardiovertierer/defibrillator mit einem kleineren verdraengungsvolumen
DE69321629T2	Optimale energiesteuerung fuer einen implantierbaren defibrillator
DE69323868C0	Herzrhythmuskorrektur mittels kurzer impulse
DE69936786T	Temporary atrial cardioversion electrode catheter
EP0406381	Bio-acoustic signal sensor
EP0515059	Implantable defibrillator system providing waveform optimization
EP0540266	Cardiac Pacemaker with Pretreatment Circuit

EP0558353	Implantable Defibrillation System with Optimum Energy Steering
EP0560569	Defibrillation and Tachycardia Detection System
EP0578700	Electrocardiographic signal processing device
EP0636041	Cardioversion Waveform Production Circuit for Tachycardia Termination
EP0642368	Treatment of Ventricular Tachycardia Using Far-Field Pulse Series
EP0642369B1	Implantable Cardioverter Defibrillator for Subcutaneous Location
EP0720496A4	Prophylactic implantable cardioverter defibrillator
EP0738171	Implantable cardioverter defibrillator (stepped cardioversion)
EP0739223	Implantable cardioverter defibrillator (extended shock duration)
EP0739224	Implantable cardioverter defibrillator (polymer thin film capacitors)
EP0751805A4	Staged Energy Storage System for Implantable Defibrillator
EP0820652	Two terminal bi-directional medical current limiter
EP-0868206-A1	Method and apparatus for temporarily electrically forcing cardiac output as a backup for tachycardia patients
EP-1035890-A1	Implantable stimulation lead for use with an ICD device having autocapture pacing features
EP1046409	An implantable cardioverter-defibrillator with automatic arrhythmia detection criteria adjustment
EP-1062987-A2	Implantable medical device
EP1084730	Implantable cardioversion device with automatic filter control

EP-1110581-A2	Implantable ventricular cardioverter/ defibrillator employing atrial pacing for preventing atrial fibrillation from ventricular cardioversion and defibrillation shocks
EP1114653	An Implantable Cardioversion Device with a Self-Adjusting Threshold for Therapy Selection
EP1127587	Dual-Chamber Implantable Cardiac Stimulation System and Device with Selectable Arrhythmia Termination Electrode Configurations and Method
EP1140279	Temporary atrial cardioversion electrode catheter
EP1155711	Method and Apparatus for Biventricular Stimulation and Capture Monitoring
EP1155712	Implantable dual site cardiac stimulation device having independent automatic capture capability
EP1205215	Implantable Cardioverter Defibrillator Having a Rechargeable, Fast-Charging Battery and Method Thereof
EP1234597	His Bundle Sensing Device and Associated Method
EP1291036	Pacing Mode to Reduce Effects of Orthostatic Hypotension and Syncope
EP1300175	XY selectable lead assembly
EP1304137	Anti-tachycardia pacing devices
EP1304138	Automatic defibrillation shock energy adjuster
EP1306105	Implantable Cardiac Therapy Device with Dual Chamber Can
EP1308182	Implantable cardiac stimulation device
EP1419731	System and Method For Monitoring Blood Glucose Levels Using an Implantable Medical Device
EP1515775 (A2)	Method and device for treating cancer with electrical therapy in conjunction with chemotherapeutic agents and radiation therapy

EP1524008 (A1)	Implantable cardiac stimulation device providing arbitrarily shaped defibrillation waveforms
EP1570880 (A1)	Left heart implantable cardiac stimulation system with clot prevention
EP1598093 (A2)	System for automated fluid monitoring
EP1614446 (A2)	Electrically forcing cardiac output temporarily in tachycardia patients
EP1647301 (A1)	Mode switching heart stimulation apparatus and method
EP1666086 (A1)	Automatic capture pacing lead
EP1747039	Partially implantable system for the electrical treatment of cancer
EP2092953 (A3)	Implantable stimulation lead for use with an ICD device having autocapture pacing features
EP2713916B1	Spinal correction system actuators
EP2854702 (A1)	Method For Detecting And Localizing Insulation Failures Of Implantable Device Leads
EP2931362A1	Arrhythmia electrotherapy device and method with provisions for mitigating patient discomfort
EP2931364A1	Coordinated medium voltage therapy for improving effectiveness of defibrillation therapy
EP547878A3	Defibrillation Pulse Generator with Small Value Capacitor
FR642369R4	Implantable Cardioverter Defibrillator Having a Smaller Displacement Volume
FR720496R1	Prophylactic implantable cardioverter defibrillator
FR751805R1	Staged Energy Storage System for Implantable Defibrillator
GB2185403B	Flexible and Disposable Electrode Belt Device

GB642369R4	Implantable Cardioverter Defibrillator Having a Smaller Displacement Volume
GB720496R1	Prophylactic implantable cardioverter defibrillator
GB751805R1	Staged Energy Storage System for Implantable Defibrillator
IT642369R4	Implantable Cardioverter Defibrillator Having a Smaller Displacement Volume
JP6158176B2	Spinal correction system actuators
JP8509385 T2	Implantable Cardioverter Defibrillator for Subcutaneous Location
JP9622811W1	Staged Energy Storage System for Implantable Defibrillator
NL642369R4	Implantable Cardioverter Defibrillator for Subcutaneous Location
NL650383R4	Implantable Cardioverter Defibrillator Having a Smaller Displacement Volume
NL720496R1	Prophylactic implantable cardioverter defibrillator
NL751805R1	Staged Energy Storage System for Implantable Defibrillator
SE0200626-0	Management of implantable devices
WO199008506	Bio-acoustic signal sensor
WO199215245	Electrocardiographic signal processing device
WO199319809	Treatment of Ventricular Tachycardia Using Far-Field Pulse Series
WO199320892	Cardioversion Waveform Production Circuit for Tachycardia Termination
WO199400193A1	Implantable Cardioverter Defibrillator for Subcutaneous Location
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